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1.0 EXECTUTIVE SUMMARY

1.1 Introduction

On November 14, 2001, USEPA sent a Notification of Additional Work - Focused Feasibility Study, Groundwater Contamination Near Site R, Sauget Area 2 Site - St. Clair County, Illinois to Steven D. Smith of Solutia Inc., the Project Coordinator for the Sauget Area 2 Sites Group. In this letter, USEPA stated that the following:

- Historical groundwater data collected by Solutia in May 2000 indicates that contaminated groundwater discharges to the Mississippi River along at least a 2,000 foot length of the east bank adjacent to Site R;
- Contaminated groundwater discharging to the Mississippi River exceeds Illinois Environmental Protection Agency (IEPA) derived water quality criteria;
- Modeling predicts approximately 680,000 kg/year of SVOCs and VOCs are discharging to the river;
- Sediment samples collected by USEPA in October and November 2001 and analyzed for VOCs and SVOCs show that sediment is contaminated with significant contributions of VOCs and SVOCs starting at the northern edge of Site R. This area is also the approximate northern boundary of the groundwater contaminant plume;
- Significant concentrations of VOCs and SVOCs in sediment continue along and south of Site R, the approximate southern boundary of the groundwater contaminant plume;
- USEPA sediment data further documents exceedances of the IEPA derived water quality criteria; and
- Groundwater data at Site R correlates well with both the type and extent of contamination found in the Mississippi River sediment.

USEPA also stated that:

> "Based on the currently available groundwater and sediment information, it is apparent that groundwater, with contaminant concentrations above acceptable levels, is discharging from Site R to the Mississippi River. USEPA has determined that an immediate CERCLA response action is necessary to restrict the migration of the groundwater contamination and prevent an unacceptable discharge of contaminated groundwater to surface water in the vicinity of Site R. USEPA believes sufficient data currently exists to evaluate response actions to address the environmental concerns in connection with the groundwater contaminant plume at Site R.

> Pursuant to Section 2.5 - Additional Work of the November 24, 2000 Administrative Order on Consent for the Sauget Area 2 Site, USEPA has determined that additional work is necessary to prepare a focused feasibility study (FS) to address the known groundwater contamination problem in the vicinity of Site R. Within 45 days of receipt of this letter, Respondent(s) shall submit to USEPA for approval a draft focused FS for the Site R groundwater contamination problem that is consistent with the attached scope of work (SOW)."

This Sauget Area 2 Focused Feasibility Study (FFS) is submitted in response to USEPA's November 14, 2001 Notification of Additional Work. Solutia is submitting this FFS, not the Sauget Area 2 Sites Group whose members declined to participate in preparation and submittal of this document. The Focused Feasibility Study addresses the discharge of impacted groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area (Figure 1-1). It is, in essence, a streamlined Feasibility Study (FS). The preamble of the NCP emphasizes the principle of streamlining which is intended to balance the desire for extensive alternatives analyses with a bias for initiating response actions as early as possible. In keeping with this principle of streamlining, the FFS only evaluates measures to abate the discharge of impacted groundwater to surface water. Consequently, the FFS will lead to an interim groundwater remedy for Sauget Area 2. A more comprehensive evaluation of the potential risks associated with Sauget Area 2 Sites O, P, Q, R and S will be performed and presented at the completion of the Sauget Area 2 Remedial Investigation/Feasibility Study (RI/FS). USEPA and the Sauget Area 2 Sites Group are currently finalizing the Support Sampling Plan that will be implemented to collect the data needed to prepare the Sauget Area 2 RI/FS.

1.2 Sites Characterization

1.2.1 Sites Description

The Sauget Area 2 Sites are located in the City of East St. Louis and the Villages of Sauget and Cahokia in St. Clair County, Illinois (Figure 2-1). Sauget Area 2 Sites consist of five inactive disposal sites: Site O, Site P, Site Q, Site R and Site S. These sites are located in an area historically used for heavy industry, including chemical manufacturing, metal refining and power generation and waste disposal. Currently the area is used for heavy industry, warehousing, bulk storage (coal, refined petroleum, lawn and garden products and grain), wastewater treatment, hazardous waste treatment, waste recycling and truck terminals. No residences are located within or adjacent to the study area.

Site O - Site O consists of four closed lagoons constructed in 1965 at the Village of Sauget Wastewater Treatment Plant and placed in operation in 1966/1967. Between 1966/67 and approximately 1978, these lagoons were used to dispose of clarifier sludge from the wastewater treatment plant. They were closed in 1980 by stabilizing the sludge with lime and covering it with approximately two feet of clean, low-permeability soil. Constituents detected in groundwater at Site O include:

VOCs	SVOCs	Metals
Benzene	4-Chloroaniline	Arsenic
2-Butanone	1,2-Dichlorobenzene	Cadmium
Chlorobenzene	1,4-Dichlorobenzene	Lead
trans-1,2-Dichloroethene	4-Methylphenol	
Methylene Chloride	Phenol	
4-methyl-2-Pentanone		
1,1,2,2-Tetrachoroethane		
Tetrachloroethene		
Toluene		
Trichloroethene		

Site P - Operated by Sauget and Company from 1973 to approximately 1984, Site P was an IEPA-permitted landfill, accepting general wastes, including diatomaceous-earth filter cake from Edwin Cooper and non-chemical wastes from Monsanto.

Site Q - Disposal started at Site Q in the 1950s and continued until the 1970s. Allegedly, Sauget and Company started operation of a landfill south of the River Terminal in 1966 and terminated operations in 1973. This facility took various wastes including municipal waste, septic tank pumpings, drums, organic and inorganic wastes, solvents, pesticides and paint sludges. It also took plant trash from Monsanto, waste from other industrial facilities and demolition debris. USEPA conducted two response actions at Site Q; one in 1995 to remove drums exposed in the riverbank in the southwestern portion of the Site and another in

1999/2000 to remove drums (3,271) and soil (17,032 tons) from two ponds located in the southeast corner of the Site. Constituents detected in groundwater at Site Q include:

VOCs

Benzene
Chlorobenzene
1,2-Dichloroethane
2-Hexanone
4-methyl-2-Pentanone
Toluene

Metals and Inorganics

Arsenic

Cyanide

SVOCs

4-Chloroaniline

Phenol
2-Chlorophenol
2, 4-Dichlorophenol
2,4,6-Trichlorophenol
Pentachlorophenol

4-Methylphenol
2,4-Dimethylphenol

2-Nitroaniline

Acenaphthylene

Site R - Industrial Salvage and Disposal, Inc. (ISD) operated the River's Edge Landfill for Monsanto from 1957 to 1977. Hazardous and non-hazardous bulk liquid and solid chemical wastes and drummed chemical wastes from Monsanto's W.G. Krummrich plant and, to a lesser degree, its' Queeny plant in St. Louis were disposed at Site R. Disposal began in the northern portion of the site and expanded southward. Wastes contained phenols, aromatic nitro compounds, aromatic amines, aromatic nitro amines, chlorinated aromatic hydrocarbons, aromatic and aliphatic carboxylic acids and condensation products of these compounds. A two to eight ft. thick, clay cover was installed on Site R in 1979 to cover the waste, limit infiltration through the landfill and prevent direct contact with the landfill material. In 1985, a 2,250 ft. long rock revetment was installed along the bank of the Mississippi River downgradient of Site R to prevent erosion of the riverbank and minimize the potential for the release of waste material from the landfill. Constituents detected in groundwater at Site R include:

VOCs

Acetone
Benzene
Bromoform
2-Butanone
Chlorobenzene

SVOCs

Aniline
2-Chloroaniline
3-Chloroaniline
4-Chloroaniline
2-Nitroaniline
3-Methylphenol
4-Methylphenol
2,4-Dimethylphenol
4-chloro-3-Methylphenol

Chloroethane
Chloroform
Chloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
Ethylbenzene
trans-1,2-Dichloroethene
Methylene Chloride
4-methyl-2-Pentanone
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
Trichloroethene
Vinyl Chloride

4-Nitroaniline

1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,4-Trichlorobenzene

Nitrobenzene
2-Nitrochlorobenzene
3-Nitrochlorobenzene
4-Nitrochlorobenzene

Phenol
2-Chorophenol
4-Chlorophenol
2,4-Dichlorophenol
2,4,6-Trichlorophenol

4-Nitrophenol

Naphthalene
2-ChloroNaphthalene

Benzoic Acid
Benzyl Alcohol
bis(2-chloroethoxy)Methane
bis(2-ethylhexyl)Phthalate
Chrysene
Fluoranthene
4-Nitrodiphenylamine
n-Nitrosodiphenyamine
Pyrene

Site S - In the mid-1960s, solvent recovery began on the Clayton Chemical property, which is now owned by the Resource Recovery Group (RRG). The waste solvents were steam-stripped resulting in still bottoms that were allegedly disposed of in a shallow, on-site excavation that is now designated Site S. Historical aerial photographs indicate that Site S was potentially a waste and / or drum disposal area.

1.2.2 Geology/Hydrology/Hydrogeology

Geologic data show that the unconsolidated deposits beneath the Sauget Area 2 Sites range from 140 feet thick near the Mississippi River to about 100 feet in the eastern part of the study area. Three distinct hydrogeologic units can be identified: 1) a shallow hydrogeologic unit (SHU); 2) a middle hydrogeologic unit (MHU); and 3) a deep hydrogeologic unit (DHU). The 20 feet thick SHU includes the Cahokia Alluvium (recent deposits) and the uppermost portion of the Henry Formation. This unit is fine-grained, silty sand with low to moderate permeability. The 30 feet thick MHU, formed by the upper to middle, medium to coarse sand portions of the Henry Formation, contains higher permeability sands than found in the overlying Shallow Hydrogeologic Unit, and these sands become coarser with depth. At the bottom of the aquifer is the DHU, which includes the high permeability, coarse-grained deposits of the lower Henry Formation. This zone is 40 feet thick. In some areas, clays with limestone fragments were encountered 10 to 15 feet above the bedrock. Evidently, these deposits are a limestone bedrock weathering residuum.

Groundwater beneath Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W. G. Krummrich plant and other industries in the Sauget area flows generally from east to west, toward the Mississippi river. Aquifer tests performed over a span of 30 years have established characteristics such as transmissivity, hydraulic conductivity, storage coefficient and groundwater velocity. Tests have been conducted for all three (3) groundwater units and are summarized as follows:

	Transmissivity gpd/ft	Hydraulic Conductivity	Storage Coefficient
Shallow Hydrogeologic Unit	141.5 gpd/ft	9.5 gpd/ft^2 (4 x 10^{-4} cm/s)	**Not Available**
Middle Hydrogeologic Unit	165,000 gpd/ft	3,300 gpd/ft^2 (1.6 x 10^{-1} cm/s)	0.04
Deep Hydrogeologic Unit	211,000 gpd/ft	2,600 gpd/ft^2 (1.2 x 10^{-1} cm/s)	0.002 to 0.100

Note: Results are averages

Groundwater is not used as a water-supply source.

1.2.3 Threatened and Endangered Species

There are two federally listed endangered species that can potentially be found at (or adjacent to) the Sites: 1) the Indiana bat (*Myotis sodalis*) and 2) the pallid sturgeon (Scaphirhynchus albus). One federally listed threatened species recorded in St. Clair County is the decurrent false aster (*Boltonia decurrens*). A federally listed species that is known to winter in the region and identified in the area is the bald eagle (*Haliaeetus leucocephalus*). The bald eagle has been recently upgraded to threatened status from endangered by the USFWS. Several state-listed bird species are likely to utilize the Sites: the black-crowned night heron (*Nycticorax nycticorax*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), great egret

(*Casmerodius albus*) and pied-billed grebe (*Podilymbus podiceps*). The great egret and pied-billed grebe are listed as threatened by the State of Illinois; the other three species are listed as endangered by the State. Only the black-crowned night heron has been sighted within two miles of the Sites.

Additionally, there are 18 federally or state (either Illinois or Missouri) listed fish species that have been historically shown to be present in the main stem of the Mississippi River in the region of the Sites. Those species include:

Alabama shad	*Alosa alabamae*	highfin carpsucker	*Carpiodes velifer*
alligator gar	Atractosteus spatula	Iowa darter	*Etheostoma exile*
bigeye shiner	*Notropis boops*	lake sturgeon	*Acipenser fulvescens*
blacknose shiner	*Notropis heterolepis*	mooneye	*Hiodon tergisus*
brown bullhead	*Ameiurus nebulosus*	northern pike	*Esox lucius*
central mudminnow	*Umbra limi*	pallid sturgeon	*Scaphirhynchus albus*
crystal darter	*Crystallaria asprella*	sicklefin chub	*Macrhybopsis meeki*
flathead chub	*Platygobio gracilis*	sturgeon chub	*Macrhybopsis gelida*
greater redhorse	*Moxostoma valenciennesi*	trout-perch	*Percopsis omiscomaycus*

1.2.4 Meteorology/Climatology

The National Climatic Data Center (NCDC) describes the areas' climate as modified continental, subject to four-season climate changes without the undue hardship of prolonged periods of extreme heat or high humidity. Normal annual precipitation for the area is slightly less than 34 inches. Winter months are the driest, with an average total of about six (6) inches of precipitation and the spring months of March through May are normally the wettest, with normal precipitation of just under 10.5 inches.

1.2.5 Groundwater Fate and Transport

Groundwater flow velocity is on the order of 0.02 feet per day (7 feet per year), 4 feet per day (1,500 feet per year) and 6 feet per day (2,200 feet per year), respectively, in the Shallow Hydrogeologic Unit, the Middle Hydrogeologic Unit and the Deep Hydrogeologic Unit. With groundwater flow rates of 4 to 6 feet per day, constituents migrating in the MHU and DHU could reach the Mississippi River in time periods as short as approximately 40 days and 25 days, respectively. Processes such as dispersion, dilution, biodegradation, adsorption, precipitation, etc. will retard or slow the movement of site-related constituents migrating toward the Mississippi River in the MHU and DHU. However, it is unlikely that these processes have much of an effect given the high groundwater flow velocities in the MHU and DHU and the short distance from Site R to the river.

1.2.6 Source, Nature and Extent of Contamination

Three known groundwater concentration highs are present in groundwater beneath and upgradient of Sauget Area 2 Site R: 1) one at Sauget Area 2 Sites R and Q (Dog Leg) immediately adjacent to the Mississippi River, 2) another at the location of Sauget Area 2 Sites O and S and 3) a third at the W.G. Krummrich plant. A review of historical data for Sites O, Q, R and S and current data for the W.G. Krummrich plant indicates that these concentration highs are, at least in part, due to the migration of leachate and/or liquid wastes from the disposal sites and spills and leaks at the Krummrich plant. Other potential sources for groundwater contamination exist the Sauget area but information on what actual contamination is present in the groundwater from such operations is not known at this time.

Constituents mobile in the groundwater system at Sauget Area 2 include:

VOCs	SVOCs	
Acetone	Acenapthylene	Dimethylphenol
Benzene	Aniline	Di-n-butylphthalate
Bromoform	Benzo(a)pyrene	Di-n-octylphthalate
2-Butanone	Benzo(k)fluoranthene	Fluouranthene
Chlorobenzene	Benzoic Acid	Hexachlorocylopentadiene
Chloroethane	Benzyl Alcohol	MethylNaphthalene
Chloroform	Bis(2-choroethoxy)methane	Methylphenol
Dichloroethane	Bis(2-chloroethyl)ether	Naphthalene
Dichloroethylene	Bis(2-ethylhexyl)phthalate	Nitrobenzene

Ethyl Benzene	Bis(2-chloroisopropyl)ether	Nitrochlorobenzene
Methylene Chloride	Chloroaniline	Nitrodiphenylamine
4-methyl-2-Pentanone	4-chloro-3-methylphenol	Nitrophenol
Trichloroethane	Chlorophenol	n-Nitrosodiphenylamine
Trichloroethylene	Chrysene	Pentachlorophenol
Tetrachloroethane	Dichlorobenzene	Phenol
Toluene	Dichlorobenzidine	Pyrene
Vinyl Chloride	Dichlorophenol	Trichlorophenol
Xylenes		

Metals

Arsenic	Chromium	Nickel
Barium	Cobalt	Vanadium
Cadmium	Lead	Zinc

Constituents mobile in groundwater at the W.G. Krummrich plant, in concentrations higher than the IEPA Tiered Approach to Cleanup Objectives (TACO) Tier 1 Industrial Criteria, are listed below:

VOCs	SVOCs	
Benzene	Chloroaniline	Nitrobiphenyl
Chlorobenzene	Chlorophenol	Nitrophenol
1,2-Dichloroethene	Dichlorobenzene	Pentachlorophenol
Ethylbenzene	Dichlorophenol	Phenol
Methyl Isobutyl Ketone	Naphthalene	Trichlorobenzene
Methylene Chloride	Nitroaniline	Trichlorophenol
Toluene	Nitrobenzene	
1,1,1-Trichloroethane		
Xylene		
Vinyl Chloride		

Estimated mass loading to the Mississippi downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area is 220,000 kg/yr (484,000 pounds per year) or 603 kg/day (1,327 pounds per day). This is lower than the estimate of 680,000 kg/year (1,496,000 pounds per year) included in USEPA's November 14, 2001 Notification of Additional Work. Since the Agency did not provide a basis for its mass-loading estimate, it is not possible to reconcile the difference between these two estimates.

1.2.7 Human Health Risk Assessment

Dynamac Corporation's Fort Lee, New Jersey office and Geraghty & Miller's Bethpage, New York office prepared a Human Health Risk Assessment for Site R using data collected during an RI/FS required by an AOC with IEPA. Using data from prior site investigations, the risk assessors identified 29 chemicals of potential concern (COPCs):

VOCs

- Benzene
- Chlorobenzene
- 1,2-Dichloroethane
- Dichloroethylene
- Methyl Chloride
- Methylene Chloride
- Tetrachloroethylene
- Vinyl Chloride

SVOCs

- Aniline
- 4-Chloroaniline

- 1,2-Dichlorobenzene
- Nitrobenzene
- 2-Nitrochlorobenzene

- Phenol
- 2-Chlorophenol
- 2,4-Dichlorophenol
- 2,4,6-Trichlorophenol
- Pentachlorophenol

- 2,4-Dimethylphenol

- Naphthalene

Pesticides/PCBs

- alpha-BHC
- PCBs

Metals

- Antimony
- Arsenic
- Beryllium
- Boron
- Nickel
- Thallium
- Cyanide

Potential exposure pathways are summarized below:

Potential Exposure Pathway	Chemical Source	Potential Exposure Scenario	Potential Receptors
Direct Contact	Clay Cap	Dermal Contact with and Incidental Ingestion of Soil	On-Site Maintenance Workers
Air	Clay Cap	Inhalation of VOCs and Dust	On-Site Maintenance Workers
Surface Water	Groundwater Discharge to Surface Water	Dermal Contact with and Ingestion of River Sediments	Trespassing Users of Mississippi River

Fish Ingestion	Commercial and Recreational Users of Mississippi River

Potential carcinogenic risks associated with realistic exposure scenarios for identified receptor groups indicated that the potential excess cancer risks for on-site workers and area residents consuming fish were less than 2.7×10^{-7} for all pathways combined. Even under worst-case exposure assumptions, the estimated excess lifetime carcinogenic risk for all pathways combined was 5.7×10^{-6}. Risk assessment results for the exposure pathways are summarized below:

Pathway	Worst-Case Exposures		Average-Case Exposures	
	On-Site Worker	**Local Resident**	**On-Site Worker**	**Local Resident**
Dermal Contact				
Surface Materials	4.5×10^{-7}	NA (1	6.2×10^{-8}	NA (1
Surface Water				
Adult	NA	1.3×10^{-6}	NA	NA
Child	NA	7.6×10^{-7}	NA	NA
Total	NA	2.1×10^{-6}	NA	NA
Incidental Ingestion				
Surface Materials	8.9×10^{-7}	NA	1.2×10^{-7}	NA
Surface Water				
Adult	NA	3.4×10^{-9}		
Child	NA	8.1×10^{-9}		
Total	NA	1.2×10^{-8}		
Inhalation				
Volatile Organics	9.5×10^{-7}	NA	1.1×10^{-8}	NA
Fish Ingestion				
Adult	NA	8.7×10^{-7}	NA	5.2×10^{-8}
Child	NA	4.9×10^{-7}	NA	2.9×10^{-8}
Total	NA	1.4×10^{-6}	NA	8.1×10^{-8}
Total	**2.3×10^{-6}**	**3.4×10^{-6}**	**1.9×10^{-7}**	**8.1×10^{-8}**
Overall Total (2	**5.7×10^{-6}**		**2.7×10^{-7}**	

Notes:

1) Not applicable, pathway not available to this receptor group.
2) Conservatively assumes that a receptor will be exposed via all pathways.

With respect to noncarcinogenic hazards, the analysis indicated that the hazard indices for all receptor groups and pathways combined were less than one for realistic exposure scenarios. Under worst-case assumptions, the combined hazard index was also less than one. Risk assessment results for the exposure pathways are summarized below:

Pathway	Worst-Case Exposures		Average-Case Exposures	
	On-Site Worker	Local Resident	On-Site Worker	Local Resident
Dermal Contact				
Surface Materials	6.2×10^{-4}	NA [1]	3.1×10^{-4}	NA [1]
Surface Water				
Adult	NA	6.1×10^{-2}	NA	NA
Child	NA	2.2×10^{-1}	NA	NA
Incidental Ingestion				
Surface Materials	2.2×10^{-3}	NA	1.1×10^{-3}	NA
Surface Water				
Adult	NA	1.7×10^{-4}		
Child	NA	2.3×10^{-3}		
Inhalation				
Volatile Organics	5.0×10^{-3}	NA	2.1×10^{-4}	NA
Fish Ingestion				
Adult	NA	5.4×10^{-2}	NA	3.0×10^{-3}
Child	NA	1.7×10^{-1}	NA	1.0×10^{-2}
Total Adult	**7.9×10^{-3}**	**1.1×10^{-1}**	**1.6×10^{-3}**	**3.0×10^{-3}**
Total Child	**NA**	**3.9×10^{-1}**	**NA**	**1.0×10^{-2}**
Overall Total [2]	**5.1×10^{-1}**		**1.5×10^{-2}**	

Notes:

1) Not applicable, pathway not available to this receptor group.
2) Conservatively assumes that a receptor will be exposed via all pathways.

1.2.8 Ecological Risk Assessment

In June 2001, Menzie-Cura and Associates completed a Baseline Ecological Risk Assessment for the Mississippi River immediately downgradient of Site R. This baseline ecological risk assessment for the aquatic habitat adjacent to the W.G. Krummrich plant in Sauget, Illinois addressed surface water and sediment in the Mississippi River adjacent to Sauget Area 2 Site R. Study area boundaries, which extended approximately 2000 feet along the riverbank and 300 feet into the river channel, were defined during a reconnaissance survey completed in September 2000 to include groundwater discharging from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W. G. Krummrich plant and other industrial facilities in the Sauget area. Surface water, sediment and fish tissues samples were collected in October and November 2000.

Potential complete exposure pathways in the study area include:

- Sediment to benthic invertebrates via direct contact and ingestion;
- Surface water to invertebrates and fish through direct contact and ingestion;
- Benthic biota to higher order predators (e.g. fish) through the food chain; and
- Fish to piscivorous fish, mammals and birds via ingestion.

COPCs included the following constituents:

	Sediment	Water	Fish
VOCs			
Acetone	●		
Benzene	●	●	
2-Butanone	●		
Carbon Disulfide	●		
Chlorobenzene	●	●	
Chloroethane	●		
Chloroform	●		
1,2-Dichloroethane	●	●	
cis-1,2-Dichloroethene	●		
Ethylbenzene	●	●	
Methylene Chloride	●		
4-methyl-2-Pentanone	●	●	
Tetrachloroethylene	●		

Toluene	•	•	
Trans-1,2-Dichloroethylene	•		
Trichloroethylene	•	•	
Vinyl Chloride	•		
Xylenes	•	•	
SVOCs			
4-Bromophenylphenylether	•		
4-Chloroaniline	•	•	
2-Chlorophenol	•	•	
1,2-Dichlorobenzene	•	•	•
1,4-Dichlorobenzene	•		•
2,4-Dichlorophenol	•	•	•
2,4-Dimethlyphenol	•	•	
2,4-Dinitrotoluene	•		
2-Methylphenol			•
3-Methylphenol	•	•	
4-Methylphenol	•	•	
Naphthalene	•		
2-Nitroaniline	•		
Nitrobenzene		•	
Phenol	•	•	
2,4,6-Trichlorophenol	•	•	
Pesticides			
alpha-BHC			•
alpha-Chlordane			•
gamma-Chlordane			•
4,4'-DDD	•		•
4,4'-DDE			•
4,4'-DDT			•
Dieldrin			•
Endosulfan I			•
Endrin			•
Endrin aldehyde			•
Heptachlor epoxide			•
Herbicides			
2,4-D	•	•	
Dicamba		•	
Dichloroprop	•	•	
MCPP	•		•
Pentachlorophenol	•	•	
2,4,5-T			•
Silvex		•	•

Dioxin • • •

Species selected as potential receptors represent the ecological community and its sensitivity to the contaminants of concern and were arrived at based, in part, on knowledge of the area and discussions with USEPA and local professional fishermen. The ecological receptors selected for evaluation included: benthic invertebrates as a prey base for fish, local fin fish, great blue heron, osprey and river otter. In this assessment, drum, gizzard shad and channel catfish represent major groups of fish in the Mississippi River. They represent a bottom feeder, forage fish and a predator/omnivore bottom-feeding fish, respectively. Two assessment endpoints were used in this ecological risk assessment: 1) sustainability (survival, growth and reproduction) of warm water fish species typical of those found in similar habitats (incorporates the assessment of aquatic invertebrates); and 2) survival, growth and reproduction of local populations of aquatic wildlife represented by osprey, great blue heron and river otter.

Menzie-Cura's Ecological Risk Assessment indicates that:

- Fish species are at risk from exposure to sediment based on the results of toxicity testing;

- Fish prey, such as planktonic invertebrates, are at risk from exposure to surface water based on toxicity tests. Planktonic invertebrates do serve as a prey base for fish species, however, the assessment assumes that they are exposed to surface water at the sediment-surface water interface. In reality, they are exposed to dynamic water concentrations reflecting dilution and dispersion in the high-energy riverine environment. Benthic organisms are also at risk from exposure to sediment based on laboratory toxicity tests. However, the inherent high-energy physical environment in the study area in the Mississippi River limits the number of benthic invertebrates. Therefore, benthic invertebrates are not abundant and are not considered an important prey component for fish at the site.

- Fish are accumulating compounds, specifically MCPP [Methyl Chlorophenoxy Propionic Acid], detected in study area sediments but not detected in reference sediments.

- There is a low potential risk to wildlife foraging on the media (sediment, surface water and fish) in the study area.

- There are a number of compounds without applicable sediment, surface water or tissue guidelines. Comparisons of study area concentrations to reference concentrations indicate that a subset is found in concentrations in study area media that exceed the concentrations in reference media.

- In general, the impacts occur within 300 feet of the shoreline. All toxicity tests resulting in potential toxicity occurred within 150 feet of shore, with the exception of one station (PDA-4) at 300 feet. This station is located downstream of the wing dam in an area where surface waters are more protected from the strong currents.

- VOCs, SVOCs, and one herbicide are elevated at the surface water stations with toxicity, and VOCs, and herbicides are elevated at the sediment stations with toxicity.

1.3 Interim Remedial Action Objectives

Based on the risks associated with the discharge of impacted groundwater to surface water downgradient of Sauget Sites O, Q (Dog Leg), R and S; Sauget Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area, the following Remedial Action Objectives were identified for the Interim Remedial Action:

- Prevent or abate actual or potential exposure to nearby human populations (including workers), animals or the food chain from hazardous substances, pollutants or contaminants;
- Prevent or abate actual or potential contamination of drinking water supplies and ecosystems;
- Achieve acceptable chemical-specific contaminant levels, or range of levels, for all applicable exposure routes;
- Mitigate or abate other situations or factors that may pose threats to public health, welfare or the environment; and
- Mitigate or abate the discharge of groundwater to the Mississippi River so that the impact is "insignificant" or "acceptable".

Focusing Interim Groundwater Remedy RAOs on the aquatic ecosystem is appropriate because sediment, surface water and fish tissue sampling, conducted in October and November 2000 as part of the W.G. Krummrich RCRA AOC, demonstrated that groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area adversely impacted the Mississippi River. Impacts due to the discharge of groundwater to surface water are confined to an area approximately 2000 feet long (coinciding with the north and south boundaries of Sauget Area 2 Site R) and 300 feet from shore immediately downgradient of Site R. Installation of a physical or hydraulic barrier downgradient of Sauget Area 2 Site R will reduce mass loading to the Mississippi River. Reduction of mass loading will abate aquatic organism exposure to impacted groundwater, contamination of ecosystems and sediment toxicity.

An Interim Groundwater Remedy can be implemented to abate aquatic impacts while the Sauget Area 2 Remedial Investigation/Feasibility Study is being performed to evaluate remedial alternatives that will abate impacts on groundwater. Once the Sauget Area 2 RI/FS is completed, a Final Groundwater Remedy can be selected.

Using "protect the river" as the primary remedial action objective for the Interim Groundwater Remedy would also reduce the impact of groundwater discharging to surface water to "insignificant" or "acceptable" levels, as required by the May 3, 2000 W.G. Krummrich RCRA AOC (USEPA Docket No. R8H-5-00-003), if groundwater from the Krummrich plant discharges to the Mississippi River at unacceptable levels.

For these reasons, the goal of the Interim Groundwater Remedy is to protect the Mississippi River by reducing mass loading to the river and, thereby, abating:

- Exposure of human populations, animals or the food chain to contaminants;
- Contamination of drinking water supplies and ecosystems;
- Chemical-specific contamination for all applicable exposure routes; and
- Threats to public health, welfare or the environment.

Mass loading, gradient control and sediment and surface water quality are appropriate performance measures for these Interim Groundwater Remedy remedial action objectives.

1.4 Identification of Interim Remedial Alternatives

General response actions for the groundwater discharge to surface water include the following:

- Institutional Controls
  - Access Restrictions
  - Warning Signs
  - Community Relations
- Engineered Barriers
  - Physical Barriers
    - Slurry Walls
    - Jet Grout Walls
  - Hydraulic Barriers
- Monitoring
  - Groundwater Water Quality Monitoring
  - Groundwater Level Monitoring
  - Bioaccumulation Monitoring

The following sections describe technology types and process options for groundwater that could satisfy the remedial action objectives for the discharge of groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

1.4.1 Institutional Controls

Institutional controls can include access restrictions to the area of interest, as well as regulations restricting specific activity within the area of interest. Institutional controls already in place include fencing of Sites 0 and R and excavation restrictions at Site R to prevent trenching without appropriate protection of construction workers. Additional institutional controls, such as posting, could be implemented to prevent recreational fishing in the affected area.

Access Restrictions - Access restrictions include physical restrictions such as the use of fencing and locked gates. Access to Site R is already controlled by the presence of fencing and locked gates. Restrictions are already in place for Site R that define requirements for training, protection and monitoring of construction and outdoor industrial workers. Industrial and construction workers doing any type of invasive work are trained for high hazard material exposure, hazardous waste site operations, advised of the complete range of chemical and physical hazards to which they may be exposed, and provided with personal protective equipment to mitigate all identified inhalation, ingestion, and dermal contact risks.

Warning Signs - Warning signs discourage access and unauthorized excavation activities. They can be posted on security fencing and in other areas as needed. Implementation will be in conjunction with the response action for the discharge of groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

Community Relations - Community relations may include an information campaign designed to ensure public awareness about the risks, if any, associated with potential ingestion of caught in the plume discharge area.

1.4.2 Engineered Barriers

Engineered barriers are designed to mitigate discharge of groundwater with contaminant concentrations in excess of standard. Engineered barriers could potentially be placed adjacent to source areas, or they could be placed near the downgradient boundary of the Sauget Area 2 Sites. Since an interim remedial action is needed to abate the impact resulting from the discharge of impacted groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area, it is appropriate to install an engineered barrier immediately adjacent to the Mississippi River downgradient of these sites.

Engineered barriers selected for screening include two physical barriers (slurry walls and jet-grouted walls) and a hydraulic barrier.

Slurry Walls - Slurry walls are subsurface barriers that mitigate the horizontal flow of contaminants and groundwater. Permanent slurry walls are generally constructed with cementitious or pozzolanic agents that are mixed with in situ or imported earthen materials. Slurry walls generally can be hanging walls, which extend to a prescribed depth below surface, or fully-penetrating walls, which terminate at or are keyed into the underlying bedrock.

Considering that affected groundwater extends to depths in excess of 100 feet, a hanging slurry wall may not be a completely effective alternative for accomplishing the remedial objective of controlling or mitigating the discharge of impacted groundwater to the Mississippi River. Consequently, a hanging slurry wall was not considered further in this analysis.

Two site-specific issues appear to make installation of a fully penetrating slurry wall impracticable: 1) keying the slurry wall into bedrock and 2) slurry trench spoil disposal. It is not practical to key a slurry wall into bedrock at the 100 to 140 foot depths required at this site. In fact, USEPA publication 542-R-98-005, *Evaluation of Subsurface Engineered Barriers at Waste Sites*, August 1998, states, "The greatest difficulty in achieving adequate key depth was encountered at sites at which fractured bedrock occurred at depths of more than 70 feet below ground surface."

Terminating the slurry wall at bedrock may be practicable because the amount of groundwater flow through weathered or fractured bedrock is likely to be a very small fraction of the flow in the alluvial aquifer. However, the second limiting issue comes into play if it is feasible to terminate the wall at bedrock. Slurry trenches are typically 2 to 3 feet wide. Consequently, construction of a 3,500 ft. long slurry wall with an average depth of 120 ft. will result in 30,000 to 50,000 cubic yards of spoil depending on trench width. Spoil disposal becomes a serious practicability issue if it can not be used as slurry trench backfill after mixing with low-permeability materials or if it can not be disposed on site. Most of the spoil will be sand-sized material, which is a suitable material for slurry trench backfill. Without compatibility testing it is not possible to determine whether or not the constituents present in the spoil will adversely affected its performance as backfill.

On-site disposal does not appear feasible unless the spoil can be stockpiled on Sauget Area 2 Site R until a final remedy decision is made on Sauget Area 2 source areas. A temporary stockpile on the wet side of the USACE floodwall may not be an appropriate management alternative for this material because of the potential adverse consequences that could result during flood conditions. Off-site disposal of 30,000 cubic yards (45,000 tons) of spoil will cost $90,000,000, assuming $2,000 per ton for transportation and disposal, if Universal Treatment Standards need to be met prior to disposal in a hazardous waste landfill.

For these reasons, a fully penetratiing slurry wall will not be considered further, based on apparent impracticability.

Jet-Grouted Walls - Jet-grouted walls are subsurface barriers that mitigate the horizontal flow of contaminants and groundwater. Permanent jet-grouted walls are generally constructed with cementitious or pozzolanic agents that are mixed with in situ soils. Mixing is accomplished by inserting a rotating grouting rod into the subsurface. Low-permeability grout is pumped through the rod under very high pressure and mixes with the in-situ soil. This creates a column of low-permeability soil from bedrock to above the water table. A wall is constructed by installing contiguous soil/grout columns along the barrier wall alignment.

Jet-grout walls generally can be hanging walls, which extend to a prescribed depth below surface, or fully penetrating walls, which terminate at bedrock. Considering that affected groundwater extends to depths in excess of 100 feet, a hanging jet-grout wall may not be a completely effective alternative for accomplishing the remedial objective of controlling or mitigating the discharge of impacted groundwater to the Mississippi River. Consequently, a hanging jet grout wall will not be considered further in this analysis. Terminating the jet-grout wall at bedrock may be practicable and is likely to achieve remedial objectives because the amount of groundwater flow through weathered or fractured bedrock is likely to be a very small fraction of the flow in the alluvial aquifer. Little or no spoil is generated during installation of a jet grout wall. As a result, a jet grout barrier wall is considered a practicable physical barrier wall technology.

Hydraulic Barriers - Hydraulic barriers consist of one or more groundwater recovery extraction wells that collect groundwater and contaminants and pump them to the surface. Hydraulic barriers provide containment both by intercepting contaminated groundwater and by providing hydraulic control. Installing a line of extraction wells along a riverbank will create a hydraulic barrier that captures impacted groundwater prior to its discharge to surface water. Design and operation of a hydraulic barrier need to be optimized to maximize the capture of impacted groundwater and minimize recharge from the Mississippi River. If the area of influence of the hydraulic barrier were to extend into the Mississippi River, pumping and treatment costs would increase significantly without a corresponding increase in environmental protection.

1.4.3 Monitoring

Groundwater Quality Monitoring - Groundwater quality samples can be collected to ensure acceptable performance of any interim remedial action taken to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area. Monitoring well clusters can be constructed on the top of the riverbank immediately downgradient of Sauget Area 2 Site R to determine mass loading to the Mississippi River. Each well cluster can consist of monitoring wells screened in the Shallow, Middle and Deep Hydrogeologic Units. Groundwater quality samples can be collected from monitoring well clusters and analyzed for VOCs, SVOCs, Herbicides, Pesticides, Metals, Total Organic Carbon (TOC) and Total Dissolved Solids (TDS). Mass loading to the Mississippi River can be determined for each hydrogeologic unit (SHU, MHU and DHU). Total mass loading can be plotted over time to track changes in the amount of mass discharging to the Mississippi River.

Groundwater Level Monitoring - Groundwater level monitoring can be done to ensure acceptable performance of any interim remedial action implemented to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area. Groundwater elevation data from water-level measurement piezometers can be used to assess whether or not gradient control is achieved if a physical or hydraulic barrier is installed to abate the discharge of impacted groundwater to the Mississippi River.

Surface Water and Sediment Monitoring - Sediment and surface water samples will be collected in the plume discharge area downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to determine the effect of any contaminants migrating through, past or beneath the barrier wall and discharging to the Mississippi River. Impact will be determined by comparing constituent concentrations to site-specific, toxicity-based, protective concentrations derived from existing sediment and surface water chemistry and toxicity data. In this context, it must be recognized that it may take some time for observable decreases in sediment concentration to occur after the installation of the barrier wall.

1.5 Detailed Analysis of Interim Remedial Alternatives

A physical or hydraulic barrier located at the downgradient edge of the impacted groundwater plume is the only effective interim remedy that will achieve the objective of protecting the Mississippi River from adverse impacts due to the discharge of groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area. For that reason, only three alternatives are compared in this Interim Groundwater Remedy Focused Feasibility Study:

- **Groundwater Alternative A - No Action**
- **Groundwater Alternative B - Physical Barrier**
  - Institutional Controls
  - Physical Barrier
  - Groundwater Treatment
  - Monitoring
    - Groundwater Quality Monitoring
    - Groundwater Level Monitoring
    - Surface Water and Sediment Monitoring
- **Groundwater Alternative C - Hydraulic Barrier**
  - Institutional Controls
  - Hydraulic Barrier
  - Groundwater Treatment
  - Monitoring
    - Groundwater Quality Monitoring
    - Groundwater Level Monitoring
    - Surface Water and Sediment Monitoring

1.5.1 Groundwater Alternative A - No Action

This alternative includes no actions to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area.

Implementation of a No Action alternative will not protect the Mississippi River from adverse ecological impact due to the discharge of impacted groundwater to surface water and the primary potential risk to human health will not be addressed. In addition, a No Action alternative is unlikely to be effective or permanent in the long-term because it does not provide for treatment beyond that afforded by natural processes. This alternative is readily implementable and there are no costs are associated with implementation.

1.5.2 Groundwater Alternative B - Physical Barrier

Institutional Controls - Institutional controls will be utilized to limit fishing in the plume discharge area. Access to the Mississippi River in the plume discharge area is limited by existing fencing at Site R, a very steep riverbank and the absence of public roads leading to this area. Additional institutional controls would include warning signs posted at the top of the riverbank in the plume discharge area and in nearby river access areas. A public education program would be implemented to inform the public that fish in the impacted groundwater discharge area may contain site-related constituents and to assure public awareness of the potential risks, if any, that may be associated with consumption of fish caught in the plume discharge area. Routine maintenance and inspection of the condition and effectiveness of the institutional controls will be performed.

Physical Barrier - A 3,500 ft. long, "U"-shaped, fully penetrating, jet grout barrier wall will be installed between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River (Figure 1-2) to abate the discharge of impacted groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area. It will extend along the entire 2,000 ft. north/south length of Site R with the arms of the "U" extending approximately 750 ft. to the east (upgradient), past the eastern boundary of Site R and terminating before the USACE floodwall.

Three partially penetrating groundwater recovery wells, capable of pumping a combined total of 303 to 724 gpm, will be installed inside the "U"-shaped barrier wall to control groundwater discharging to the wall. Modeling indicates that groundwater discharges to the Mississippi River for high, average and low river stage conditions are 303, 535 and 724 gpm, respectively. Pumping rates will be controlled by river stages. A river stage gage will be installed in the Mississippi River downgradient of Site R. Water level information from the gage will be sent by telemetry to a pump controller that will adjust variable frequency drives to produce the required pumping rates to control the groundwater discharging into the barrier wall.

Groundwater Treatment - Extracted groundwater will be routed to the American Bottoms Regional Treatment Facility (ABRTF) via subsurface pipeline installed in existing pipeline easements starting at the north end of Sauget Area 2 Site R and extending to the western boundary of Lot F. At the western boundary of Lot F, property owned by Solutia, the pipeline will turn south and connect with the Village of Sauget trunk sewer leading to the PChem Plant. Existing easements and access points for raw material and finished product pipelines allows ready installation of the extracted groundwater pipeline beneath the floodwall and railroad tracks and avoids the time consuming process of obtaining access and easements on alternative routes.

A local limits evaluation indicates the potential for two constituents (4-Chloroaniline and 4-Nitroaniline) to pass through the ABRTF without treatment and the potential for four constituents (Aniline, 2-Chlorophenol, Pentachlorophenol and Phenol) to interfere with treatment system operation. These constituents were successfully treated (removals of 90 percent or greater) in a pilot-scale groundwater treatability study performed at Sauget Area 2 Site R in the early 1990s. Since the American Bottoms Regional Treatment Facility uses the same treatment processes (biodegradation and carbon adsorption) as were used in the Sauget Area 2 Site R groundwater treatability study, the POTW should be able to treat this groundwater discharge. American Bottoms submitted an NPDES permit renewal application to IEPA in October 2001 that included this groundwater discharge.

Groundwater Quality Monitoring - Groundwater quality samples will be collected downgradient of the physical barrier to determine mass loading to the Mississippi River resulting from any contaminants migrating through, past or beneath the barrier wall. Groundwater quality samples will be collected from four monitoring well clusters and analyzed for VOCs, SVOCs, Herbicides, Pesticides and Metals. TOC and TDS will also be determined for each sample. Monitoring well clusters will be constructed on the top of the riverbank downgradient of the following locations immediately adjacent to the Mississippi River (Figure 1-2):

- 200 ft. South of the North End of Sauget Area 2 Site R
- Halfway Between North and Center Pumping Well

- Halfway Between South and Center Pumping Well
- 200 Ft. North of the South End of Site R"

Each well cluster will consist of monitoring wells screened in the Shallow, Middle and Deep Hydrogeologic Units. A total of twelve monitoring wells will be installed. Figure 1-2 depicts the planned monitoring well network. Soil samples from borings completed for the purpose of installing groundwater-quality monitoring wells and groundwater extraction wells and/or obtaining geotechnical information on subsurface soils will be screened for the presence of NAPL. In addition, existing wells downgradient of Sauget Area 2 Site R will be measured for accumulation of NAPL.

Groundwater samples will be collected quarterly for five years and semiannually thereafter.

Mass loading to the Mississippi River will be determined for each hydrogeologic unit (SHU, MHU and DHU). Total mass loading will be plotted over time to track changes in the amount of mass discharging to the Mississippi River.

Groundwater Level Monitoring - Groundwater level monitoring will be done to ensure acceptable performance of the physical barrier installed to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area. Soil samples from the borings completed for the purpose of installing water-level piezometers will be screened for the presence of NAPL. In addition, existing wells downgradient of Sauget Area 2 Site R will be measured for accumulation of NAPL.

Groundwater levels will be monitored at the physical barrier to determine if gradient control is achieved. Gradient control will be determined by:

- Comparing the water-level elevations in one pair of fully penetrating water-level piezometers installed at the northwest corner of the physical barrier and one pair of piezometers installed at its southwest corner (Figure 1-2). One piezometer of each pair will be installed inside the barrier wall and one will be installed outside it. Pumping wells and water-level piezometers will be located on the same north/south line. Pumping rates will be adjusted so that the water-level elevation in the inside piezometer at each corner of the barrier wall is the same as the water-level elevation in the outside piezometer. This will ensure that groundwater discharging to the physical barrier is controlled. Electronic water-level recorders will be installed in each piezometer and telemetry will be used to send the water-level data to the pump controller. Groundwater elevations inside and outside each corner of the barrier wall will be compared by the pump controller and pumping rates will be adjusted to maintain the same groundwater level elevation inside the barrier wall as measured outside the wall.

- Comparing the water-level elevations in one pair of fully-penetrating water-level piezometers installed halfway between the south pumping well and the center pumping well and one pair installed halfway between the north pumping well and the center pumping well. One piezometer of each pair will be installed on the downgradient side of the barrier wall and the other piezometer will be installed on the upgradient side (Figure 1-2). Pumping wells and water-level piezometers on the upgradient side of the barrier wall will be located on the same north/south line. Water-level piezometers downgradient of the barrier wall will be installed 20 feet away from the wall. Pumping rates will be adjusted so that the water-level elevation in the upgradient piezometer of each pair is the same as the water-level elevation in the downgradient piezometer. This will ensure that groundwater discharging to the physical barrier is controlled. Electronic water-level recorders will be installed in each piezometer and telemetry will be used to send the water-level data to the pump controller. Groundwater elevations inside and outside the north/south portion of the barrier wall will be compared by the pump controller and pumping rates will be adjusted to maintain the same groundwater level elevation inside the barrier wall as measured outside the wall.

- Groundwater levels will be measured manually on a quarterly basis in existing wells B-21B, B-22A, B-24C, B-25A, B-25B, B-26A, B-26B, B-28A, B-28B and B-29B to supplement gradient control information from the water-level piezometers. Wells B-27B, B-23B, B-30B and B-31B and B-31C no longer exist and, therefore, cannot be used to supplement the groundwater level data set.

Physical barrier pumping rates will not be increased to the point where water levels inside the barrier wall are lower that water levels outside the barrier wall. Operating the physical barrier in this manner effectively turns it into a large collection well that will have little or no effect on achieving short-term or long-term performance measures. However, it will potentially have a large adverse impact on the ability of the POTW to treat the increase flow from the hydraulic barrier. Treatment costs will also substantially increase without any corresponding increase in environmental protection.

Surface Water and Sediment Monitoring - Sediment and surface water samples will be collected in the plume discharge area downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to determine the effect of any contaminants migrating through, past or beneath the barrier wall and discharging to the Mississippi River. Impact will be determined by comparing constituent concentrations to site-specific, toxicity-based, protective concentrations derived from existing sediment and surface water chemistry and toxicity data. An Apparent Effects Threshold approach will be used to derive site-specific, protective constituent concentrations for sediments and a Toxic Units approach will be used to derive site-specific, protective constituent concentrations for surface water.

Surface water and sediment samples will be collected at Sediment Sampling Stations - 2, 3, 4, 5 and 9, where toxicity was observed in October/November 2000, and analyzed for VOCs, SVOCs, Herbicides, Pesticides and Metals. Constituent concentrations will be plotted as a function of time and compared to the site-specific, toxicity-based, protective concentrations to determine progress toward achieving these targets.

Sediment and surface water sampling will be conducted twice a year, once during the summer low flow period and once during the winter low flow period, when groundwater discharge to the Mississippi River is high.

Cost - The 30-year cost for this alternative, including capital costs, monitoring and reporting costs and annual maintenance costs, on a present value (PV) basis is as follows.

Description	Capital Cost	O&M Cost (PV)	Total Cost (PV)
Institutional Controls	0	248,181	248,181

Monitoring	80,924	1,764,603	1,845,527
Hydraulic Barrier	6,721,973	323,821	7,045,794
Groundwater Treatment	0	17,446,864	17,446,864
Total	$6,802,897	$19,783,469	$26,586,366

1.5.3 *Groundwater Alternative C* - Hydraulic Barrier

Institutional Controls - Institutional controls are discussed in Section 1.5.2.

Hydraulic Barrier - Three partially penetrating groundwater recovery wells, capable of pumping a combined total of 606 to 1,448 gpm, will be installed downgradient of Sauget Area 2 Site R to abate discharge of impacted groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to the point where the impact on the Mississippi River is reduced to acceptable levels. Modeling indicates that groundwater discharges to the Mississippi River for high, average and low river stage conditions are 160, 535 and 880 gpm, respectively (Volume II - Design Basis and Design). Capture zone theory indicates that a pumping rate of twice the Darcy flow is needed to control the impacted groundwater downgradient of Site R. Consequently, hydraulic barrier pumping rates need to vary from 606 to 1,448 gpm to control groundwater discharge to surface water.

Groundwater Treatment - Extracted groundwater will be routed to the American Bottoms Regional Treatment Facility for treatment. A local limits evaluation indicates that constituents that may pass through without treatment or interfere with treatment as the same as those identified for the physical barrier.

Groundwater Quality Monitoring - Groundwater quality monitoring will be performed as described in Section 1.5.2.

Groundwater Level Monitoring - Groundwater level monitoring will be done to ensure acceptable performance of the hydraulic barrier installed to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S;

Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

Groundwater levels will be monitored at the hydraulic barrier to determine if gradient control is achieved. Gradient control will be determined by comparing the water-level elevations in two fully penetrating water-level piezometers to groundwater levels in two downgradient monitoring well clusters adjacent to the Mississippi River (Figure 1-3). One piezometer will be installed half way between the north pumping well and the center pumping well; the other will be installed halfway between the south pumping well and the center pumping well (Figure 1-3). Pumping wells and water-level piezometers will be located on the same north/south line. Pumping rates will be adjusted so that the water-level elevation in the two piezometers is one foot less that the water level in the Shallow, Middle and Deep Hydrogeologic Units. This ensures that discharge of impacted groundwater to the Mississippi River is controlled.

Electronic water-level recorders will be installed in each piezometer and telemetry will be used to send the groundwater-level data to the pump controller. Electronic water-level recorders will be installed in the two monitoring well clusters downgradient of the two gradient control water level piezometers to determine groundwater level elevation at the riverbank. Telemetry will be used to send this groundwater level information to the pump controller. Groundwater elevation at the riverbank and groundwater elevation in the gradient control piezometers will be compared by the pump controller and hydraulic barrier pumping rates will be adjusted to maintain a one foot negative differential between them.

Hydraulic barrier pumping rates will not be increased if water levels in the two monitoring-well clusters downgradient of the water-level piezometers are at or below river level elevation. Pumping river water will have little or no effect on achieving short-term or long-term performance measures, however, it will potentially have a large adverse impact on the ability of the POTW to treat the increase flow from the hydraulic barrier. Treatment costs will also substantially increase without any corresponding increase in environmental protection.
One fully penetrating water-level measurement piezometers will be installed north of the northern pumping well and one piezometer will be installed south of the southern pumping well to determine the width of the gradient control zone created by the hydraulic barrier (Figure 1-3).

Surface Water and Sediment Monitoring – Surface water and sediment monitoring will be performed as described in Section 1.5.2.

Cost - The 30-year cost for this alternative, including capital costs, monitoring and reporting costs and annual maintenance costs, on a present value (PV) basis is as follows.

Description	Capital Cost	O&M Cost (PV)	Total Cost (PV)
Institutional Controls	0	248,181	248,181
Monitoring	80,924	1,764,603	1,845,527
Hydraulic Barrier	458,679	565,142	1,023,821
Groundwater Treatment	0	47,220,670	47,220,670
Total	$539,603	$49,798,596	$50,338,199

1.6 Comparative Analysis of Interim Remedial Alternatives

Groundwater Remedial Alternatives A (No Action), B (Physical Barrier) and C (Hydraulic Barrier) were compared to one another to identify the relative advantages and disadvantages of each. A forced ranking system was used to identify the alternative that best achieves the requirements of the seven evaluation criteria used to evaluate remedial alternatives. In this forced ranking system, the alternative that best meets the requirements of a criterion was awarded a score of 1, the second best alternative was awarded a score of 2 and the third best alternative was awarded a score of 3. Using this ranking method, the alternative with the lowest score is the one that best meets the requirements of the seven criteria. The comparative analysis is summarized in the following table:

	Alternative A (No Action)	Alternative B (Physical Barrier)	Alternative C (Hydraulic Barrier)

Overall Protection of Human Health and the Environment	3	1	2
Compliance with ARARs	3	1	2
Long-term Effectiveness and Permanence	3	1	2
Reduction of Toxicity, Mobility or Volume Through Treatment	3	1	2
Subtotal	**12**	**4**	**8**
Short-Term Effectiveness	3	2	1
Implementability	1	3	2
Cost	1	2	3
Subtotal	**5**	**7**	**6**
Total Score	**17**	**11**	**14**

While Alternative A is clearly lower cost and more readily implementable, Alternatives B and C are more effective short term and are the better alternatives for protecting public health and the environment, complying with ARARs, providing long-term effectiveness and permanence and reducing mobility, toxicity or volume. Alternative B scores higher than Alternative C because it provides more long-term effectiveness and permanence and reduction of mobility, toxicity and volume. Alternative B and Alternative C can achieve compliance with ARARs if the Agency considers it appropriate to waive chemical-specific ARARs as allowed by guidance. Alternative B is considered to be better able to achieve ARARs than Alternative C.

No costs are associated with Alternative A. Estimated costs for Alternative B and Alternative C are summarized below:

Project Element	Alternative B (Physical Barrier)	Alternative C (Hydraulic Barrier)

Institutional Controls	248,181	248,181
Monitoring	1,845,527	1,845,527
Barrier	7,045,794	1,023,821
Groundwater Treatment	17,446,864	47,220,670
30-Year Present Value Cost	$26,586,366	$50,338,199

Alternative B ($26.6MM) is significantly less expensive than Alternative C ($50.3MM) on a 30-year present value basis and it provides greater protection of public health and the environment.

2.0 SITES CHARACTERIZATION

The Sauget Area 2 Sites are located in the City of East St. Louis and the Villages of Sauget and Cahokia in St. Clair County, Illinois. The Sauget Area 2 study area is east of the Mississippi River and south of the MacArthur bridge railroad tracks (Figure 2-1). The study area is west of Route 3 (Mississippi Avenue) and north of Cargill Road.

Site	Former Use	Municipality
Site O	Sewage Sludge Dewatering	Village of Sauget
Site P	Municipal and Industrial Waste Disposal	City of East St. Louis Village of Sauget
Site Q	Municipal and Industrial Waste Disposal	Village of Sauget Village of Cahokia
Site R	Industrial Waste Disposal	Village of Sauget
Site S	Chemical Reprocessing Waste Disposal	Village of Sauget

These Sites are located in an area historically used for heavy industry, including chemical manufacturing, metal refining and power generation and waste disposal. Currently the area is used for heavy industry, warehousing, bulk storage (coal, refined petroleum, lawn and garden products and grain), wastewater treatment, hazardous waste treatment, waste recycling and truck terminals. Four commercial establishments are located at the north end of the study area. No residences are located within the study area. Residential areas closest to Sauget Area 2 are approximately 3,000 feet east of Site P and about 3,000 feet east of Site O. These residential areas are located, respectively, in East St. Louis and Cahokia.

2.1 Sites Description and Background

2.1.1 Sites Location and Physical Setting

Sauget Area 2 is situated in a floodplain of the Mississippi River called the American Bottoms (Figure 2-1). It is located on the eastern side of the river directly opposite St. Louis, Missouri.

As a whole, the floodplain encompasses 175 square miles, is 30 miles long, and has a maximum width of 11 miles. It is bordered on the west by the Mississippi River and on the east by bluffs that rise 150 to 200 feet above the valley bottom. The floodplain is relatively flat and generally slopes from north to south and from east to west. Land surface lies between 400 and 445 feet above mean sea level (MSL).

Locally, the topography consists of nearly flat bottomland with slight irregularities. Elevations across the study area range from 400 to 430 feet MSL and the land surface trends in a southeastward/northwestward direction. Land surface elevations are highest adjacent to the Mississippi River (EL 430 ft MSL) and decrease to EL 400 to 410 ft MSL approximately 1,000 to 1,500 feet east of the river.

Sauget Area 2 consists of five inactive disposal sites: Site O, Site P, Site Q, Site R and Site S. The location of each of these disposal sites is described below and shown on Figure 2-1.

2.1.1.1 Site O

Site O, located on Mobile Avenue in Sauget, Illinois, occupies approximately 20 acres of land to the northeast of the American Bottoms Regional Wastewater Treatment Facility (ABRTF). An access road to the ABRTF runs through the middle of the site. In 1952, the Village of Sauget Waste Water Treatment Plant began operation at this location. In addition to providing treatment for the Village of Sauget, the plant treated effluent from the various Sauget industries.

2.1.1.2 Site P

Site P, which is bounded by the Illinois Central Gulf Railroad tracks, the Terminal Railroad Association tracks and Monsanto Avenue, occupies approximately 20 acres of land located in the City of East St. Louis and the Village of Sauget.

2.1.1.3 Site Q

Site Q, a former subsurface and surface disposal area, occupies approximately 90 acres in the Villages of Sauget and Cahokia. This Site is divided by the Alton and Southern Railroad into a northern portion and a southern portion. The northern portion consists of approximately 65 acres bordered on the north by Site R and Monsanto Avenue. The northern portion is bordered on the south by the main track of the Alton and Southern Railroad and property owned by Patgood Inc. On the east, the northern portion of the site is bordered by the Illinois Gulf Central Railroad and the US Army Corps of Engineers (USACE) flood control levee and on the west the Site is bordered by the Mississippi River.

The southern portion consists of approximately 25 acres, north of Cargill Road and south of the Alton and Southern Railroad. The southern portion is bounded on the west by a 10-ft wide easement owned by Union Electric for transmission lines and a spur track of the Alton and Southern Railroad to the Fox Terminal. A barge terminal operated by St. Louis Grain Company is located between the Union Electric easement, the spur track and the Mississippi River. Southern Site Q is bordered on the east by the Illinois Central Gulf Railroad and the flood control levee.

2.1.1.4 Site R

Site R, a closed industrial-waste disposal area owned by Solutia Inc, is located between the flood control levee and the Mississippi River in Sauget, Illinois. Its northern border is Monsanto Avenue and its southern border is Site Q. This site is now known as the "River's Edge Landfill". The former landfill occupies approximately 22 acres of the 36-acre site. A portion of Site Q, known as the "Dog Leg", is located to the east of Site R.

2.1.1.5 Site S

Site S, located southwest of Site O, is a small disposal site less than one acre is size. Allegedly, the property is or was owned by the Village of Sauget, Clayton Chemical and the Resource Recovery Group.

2.1.2 Present and Past Facility Operations and Disposal Practices

2.1.2.1 Site O

During its operation, the Village of Sauget treatment plant received and treated industrial and municipal wastewater. Approximately 10 million gallons per day of wastewater was treated most of which was from area industries. Four lagoons were constructed at the wastewater treatment plant in 1965 and placed in operation in 1966/1967. Between 1966/67 and approximately 1978, these lagoons were used to dispose of clarifier sludge from the wastewater treatment plant. They were designated as Site O during a site investigation conducted by IEPA in the 1980s. The lagoons were closed in 1980 by stabilizing the sludge with lime and covering it with approximately two feet of clean, low-permeability soil. Currently, the lagoons are covered with clean, low-permeability soil and are vegetated.

Parties that EPA alleges discharged to the Sauget Wastewater Treatment Plant during the time period that the sludge lagoons were in operation included, at a minimum:

- Amax Zinc Corporation,
- American Zinc Company
- Cerro Copper Products Company
- Clayton Chemical Co.
- Darling Fertilizer
- Ethyl Petroleum Additives, Inc.
- Midwest Rubber Reclaiming
- Mobil Oil Corporation
- Monsanto Company
- Rogers Cartage Company
- Wiese Planning and Engineering

Parties that own and/or operate, or previously owned and/or operated, portions of Site O include:

- Village of Sauget
- Sauget Sanitary Development and Research Association

2.1.2.2 Site P

Site P was operated by Sauget and Company as an IEPA-permitted landfill from 1973 to approximately 1984 accepting general wastes, including diatomaceous earth filter cake, from Edwin Cooper (now Ethyl Corporation) and non-chemical wastes from Monsanto. IEPA inspections documented the presence of drums labeled "Monsanto ACL-85, Chlorine Composition," drums labeled phosphorus pentasulfide from Monsanto and Monsanto ACL filter residues and packaging. Site P is currently inactive and partially covered, however, access to the site is not restricted.

Parties that USEPA alleges to have generated, disposed of, released into and/or transported wastes to Site P include:

- Edwin Cooper Petroleum Additives
- Kerr McGee Chemical Company
- Monsanto Chemical Company

USEPA alleges that parties who potentially own, previously owned and/or operated Site P include:

- Cahokia Trust Properties
- Chicago Title & Trust Company
- City of East St. Louis
- Gulf-Mobile & Ohio Railroad
- Magna Trust
- Metro East Sanitary District
- Norfolk Southern
- SI Enterprises
- Sauget and Company
- Solutia
- Southern Railway System
- Union Electric Company

2.1.2.3 Site Q

Disposal started at Site Q in the 1950s and continued until the 1970s. Allegedly, Sauget and Company started operation of a landfill south of Monsanto's River Terminal in 1966 and terminated operations in 1973. This facility took various wastes including municipal waste, septic tank pumpings, drums, organic and inorganic wastes, solvents, pesticides and paint sludges. It also took plant trash from Monsanto, waste from other industrial facilities and demolition debris.

Most of Site Q is covered with highly permeable black cinders. Eagle Marine Industries and Peavy Company, a division of Con-Agra, operate barge terminal facilities in the central part of the northern portion of Site Q. The southern portion of Site Q is used for reclaiming rebar from concrete. A 10-acre site on the northern portion of Site Q is currently used by Rivercity Landscape Supply as a bulk storage terminal for lawn and garden products. Raw landscape products such as mulch, rock and soil are also processed and packed on this portion of the site.

Access to some portions of the site is restricted by fencing and gates. Other parts of the site have unrestricted access.

Site Q is on the west side of the USCOE floodwall. In 1993, during the highest recorded flood in St. Louis' history, Site Q was flooded. USEPA conducted a CERCLA removal action at the northern portion of Site Q in 1995. USEPA conducted a second CERCLA removal action at the southern portion of Site Q beginning in October of 1999 and into early 2000. During this removal action, USEPA excavated over 3,200 drums and over 17,000 tons of contaminated soils containing metals, PCBs, and organics. High-concentration excavated material was transported by rail to Oklahoma for disposal at SafetyKleen's Lone Elk hazardous waste landfill. Low-concentration excavated material was transported to the Milam Recycling and Disposal Facility in East St. Louis, Illinois.

EPA alleges that the following parties potentially generated, disposed of, released into and/or transported wastes to Site Q;

- AALCO Wrecking Company, Inc.
- Abco Trash Service
- Able Sewer Service
- Ajax Hickman Hauling
- Atlas Service Company
- Banjo Iron Company
- Barry Weinmiller Steel Fabrication
- Becker Iron & Metal Corporation
- Belleville Concrete Cont. Company
- Bi-State Parks Airport
- Bi-State Transit Company
- Boyer Sanitation Service
- Browning-Ferris Industries of St. Louis
- C&E Hauling
- Cargill Inc.
- Century Electric Company
- Circle Packing Company
- Clayton Chemical Company
- Corkery Fuel Company
- Crown Cork & Seal Company, Inc.
- David Hauling
- Dennis Chemical Company, Inc
- Edgemont Construction
- Edwin Cooper Inc.
- Eight & Trendy Metal Company
- Evans Brothers
- Finer Metals Company
- Fish Disposal
- Fruin-Colnon Corporation
- Gibson Hauling
- H.C. Fournie Inc.
- H.C. Fournie Plaster
- Hilltop Hauling
- Huffmeier Brothers
- Hunter Packing Company
- Illinois Department of Transportation
- Inmont Corporation
- Lefton Iron & Metal Company
- Mallinckrodt Chemical
- Midwest Sanitation
- Mississippi Valley Control
- Monsanto Company
- Myco-Gloss
- Obear Nestor

- Disposal Service Company.
- Dore Wrecking Company
- Dotson Disposal "All" Service
- Dow Chemical
- Patgood
- Roy Baur
- Thomas Byrd
- Trash Men Inc.
- United Technologies Corporation
- U.S. Paint Corporation

EPA alleges that the following parties potentially own, previously owned and/or operated Site Q include:

- Cahokia Trust Properties
- ConAgra, Inc. (leassee)
- Eagle Marine Industries Inc.
- Industrial Salvage & Disposal Company
- Peavey Company
- Phillips Pipe Line Company
- Pillsbury Company (leasee)
- Sauget & Company
- Union Electric Company
- Village of Cahokia
- Village of Sauget

2.1.2.4 Site R

Industrial Salvage and Disposal, Inc. (ISD) operated the River's Edge Landfill for Monsanto from 1957 to 1977. Hazardous and non-hazardous bulk liquid and solid chemical wastes and drummed chemical wastes from Monsanto's W.G. Krummrich plant and, to a lesser degree, its' Queeny plant in St. Louis were disposed at Site R. Disposal began in the northern portion of the site and expanded southward. Wastes contained phenols, aromatic nitro compounds, aromatic amines, aromatic nitro amines, chlorinated aromatic hydrocarbons, aromatic and aliphatic carboxylic acids and condensation products of these compounds.

Access to Site R is restricted by fencing and is monitored by Solutia plant personnel.

Parties who allegedly own, previously owned and/or operated Site R include:

- Cahokia Trust Properties
- Monsanto Company
- Solutia Inc
- Sauget and Company

2.1.2.5 Site S

In the mid-1960s, solvent recovery began on the Clayton Chemical property, which is now owned by the Resource Recovery Group (RRG). The waste solvents were steam-stripped resulting in still bottoms that were allegedly disposed of in a shallow, on-site excavation that is now designated Site S. In 1983, IEPA modified Clayton Chemical's permit to allow acceptance and distillation of the following spent solvents with a minimum solvent content of 30 percent:

- Spent halogentated-solvents including Tetrachloroethylene; Trichloroethylene; 1,1,1-Trichlroethane and Methylene Chloride;
- Spent nonhalogenated-solvents including Xylene, Acetone, Ethyl Acetate, Toluene and Methyl Ethyl Ketone; and
- Spent high-flash point, nonhalogenated solvents including Mineral Spirits, Glycol Ether and heavy Naphtha.

Historical aerial photographs indicate that Site S was potentially a waste and/or drum disposal area. The northern portion of the site is grassed and its southern portion is covered with gravel and fenced.

2.1.3 Geology/Hydrology/Hydrogeology

2.1.3.1 Geology

The American Bottoms are underlain by unconsolidated valley fill composed of recent alluvium, known as the Cahokia Alluvium, which overlies a unit of glacial material known as the Henry Formation. The Cahokia Alluvium is approximately 40 feet thick and consists of unconsolidated, poorly-sorted, fine-grained material with some local sand and clay lenses. These alluvial deposits unconformably overlie the Henry Formation, which is composed of medium to coarse sand and gravel that increases in grain size with depth. This unit is approximately 95 feet thick and generally becomes thinner with increasing distance from the Mississippi River.

The valley fill throughout the floodplain is underlain by a bedrock system of Mississippian and Pennsylvanian age. The bedrock consists primarily of limestone and dolomite with some sandstone and shale, and is older in the central and western sections of the American Bottoms.

Cross sections showing regional geology are provided as Figures 2-2 and 2-3.

Two types of water-bearing formations exist in the American Bottoms: unconsolidated and consolidated. The unconsolidated formations (predominantly silt, sand, and gravel) are those that lie between the ground surface and the bedrock/gravel interface. The thickness of the unconsolidated formation varies throughout the area, but is typically estimated to be approximately 100 feet. Finer-grained sediments generally dominate at the ground surface and become coarser and more permeable with depth, creating semi-confined conditions within the aquifer. Thus, permeability and porosity increase in the unconsolidated formation with depth. The consolidated formations are deep bedrock units of limestone and dolomite that exhibit low permeability and are not considered to be a significant source for groundwater in the area.

As reported in "Groundwater Management in the American Bottoms, Illinois," hydraulic properties of the unconsolidated aquifer have been determined from 10 aquifer tests and 100 specific capacity tests conducted on industrial, municipal, irrigation and relief wells. The coefficient of storage for the aquifer ranged from 0.002 to 0.155. Reported hydraulic conductivity values average 3,000 gallons per day per square foot (gpd/ft^2) which is equivalent to 1.4×10^{-1} cm/s.

Recharge to the aquifer occurs through four (4) sources: precipitation, infiltration from the Mississippi River, inflow from the buried valley channel of the Mississippi River, and subsurface flow from the bluffs that border the floodplain on the east.

2.1.3.2 Hydrology

The Mississippi River, bordering the American Bottoms to the west, is the major surface-water body draining the area. It is fed by a complex network of natural and artificial channels that was extensively improved throughout the 20^{th} Century. According to an investigation of groundwater resources conducted by the Illinois State Water Survey Division, at least 40 miles of improved drainage ditch have been constructed and the natural lake area in the center of the floodplain has been reduced by more than 40 percent.

2.1.3.3 Hydrogeology

Sauget Area 2 is located in the southwestern section of the American Bottoms floodplain. More specifically, it is situated south of East St. Louis, and extends approximately three-quarters to one mile east of the eastern bank of the Mississippi River. The stratigraphy beneath the site is much like that of the rest of the floodplain. The Cahokia Alluvium is about 30 feet thick and is a fine silty sand that is gray and brown in color. Below this, the unconsolidated deposits of the Henry Formation are present. Locally, the Henry Formation is characterized by medium-to-coarse sand that becomes coarser and more permeable with depth. The thickness of this unit ranges from 140 feet near the river to about 100 feet on the east side of the site. The groundwater level is currently between 10 to 20 feet below ground surface, but fluctuates during times of heavy and light precipitation. Cross sections showing site-specific geology are provided as Figures 2-4, 2-5 and 2-6.

Geologic data show that the unconsolidated deposits range from 140 feet thick near the river to about 100 feet in the eastern part of the study area. At most locations, the contact between Cahokia Alluvium and the Henry Formation cannot be distinguished. However, three distinct hydrogeologic units can be identified: 1) a shallow hydrogeologic unit (SHU); 2) a middle hydrogeologic unit (MHU); and 3) a deep hydrogeologic unit (DHU). The 20 feet thick SHU includes the Cahokia Alluvium (recent deposits) and the uppermost portion of the Henry Formation. This unit is primarily an unconsolidated, fine-grained silty sand with low to moderate permeability. The 30 feet thick MHU is formed by the upper to middle, medium to coarse sand portions of the Henry Formation. It contains a higher permeability sand than found in the overlying shallow hydrogeologic unit, and these sands become coarser with depth. At the bottom of the aquifer is the DHU, which includes the high permeability, coarse-grained deposits of the lower Henry Formation. This zone is 40 feet thick. In some areas, clays with limestone fragments were encountered 10 to 15 feet above the bedrock. Evidently, these deposits are a limestone bedrock weathering residuum.

Groundwater beneath the CPA flows generally from east to west, toward the Mississippi river. Horizontal groundwater gradients beneath Area 1 average about 0.001 feet per foot (ft/ft) to the west. Downward vertical gradients occur on parts of the site, with varying magnitudes depending on location and season.

Aquifer tests performed over a span of 30 years have established characteristics such as transmissivity, hydraulic conductivity, storage coefficient and groundwater velocity. Tests have been conducted for all three (3) groundwater units and are summarized as follows:

	Transmissivity gpd/ft	Hydraulic Conductivity	Storage Coefficient
Shallow Hydrogeologic Unit	141.5 gpd/ft	9.5 gpd/ft^2 (4 x 10^{-4} cm/s)	**Not Available**
Middle Hydrogeologic Unit	165,000 gpd/ft	3,300 gpd/ft^2 (1.6 x 10^{-1} cm/s)	0.04
Deep Hydrogeologic Unit	211,000 gpd/ft	2,600 gpd/ft^2 (1.2 x 10^{-1} cm/s)	0.002 - 0.100

Note: Results are averages."

2.1.4 Current and Past Groundwater Usage in the Study area

Historically, groundwater from the American Bottoms aquifer was a major source of water for the area and was used for industrial, public, and irrigation purposes. Groundwater levels prior to industrial and urban development were near land surface. Intensive industrial withdrawal and use and construction of a system of drainage ditches, levees, and canals to protect developed areas lowered the groundwater elevation for many years. However, by the mid-1980s, the groundwater levels increased due to reduced pumpage, high river stages, and high precipitation. Currently, no groundwater is being pumped from the American Bottoms aquifer in the vicinity of Sauget Area 2 for public, private or industrial supply purposes.

The source of drinking water for area residents is an intake in the Mississippi River. This intake is located at River Mile 181, approximately three miles north of Sauget Area 2. The drinking water intake is owned and operated by the Illinois American Water Company (IAWC) of East St. Louis, and it serves the majority of residences in the area. IAWC supplies water to Sauget. The Commonfields of Cahokia Public Water District purchases water from IAWC and distributes it to portions of Cahokia and Centerville Township. The Cahokia Water Department also purchases water from IAWC and distributes it to small residential areas in the west and southwest portions of Cahokia. Cahokia and Sauget both have city ordinances that prohibit use of groundwater as potable water. Public water supply is the exclusive potable water source in Sauget Area 2.

The nearest downstream surface-water intake on the Illinois side of the Mississippi River is located at River Mile 110, approximately 68 miles south of Sauget Area 2. This intake supplies drinking water to residents in the Town of Chester and surrounding areas in Randolf County, Illinois. The nearest potentially impacted public water supply on the Missouri side of the river is located at River Mile 149, approximately 29 miles south of the study area. The Village of Crystal City, Missouri (pop. 4,000), located 28 miles south of the area, utilizes a Ranney well adjacent to the Mississippi River as a source for drinking water.

Although agricultural land is found throughout the immediate project area, this land is apparently not irrigated. The nearest irrigated land, other than residential lawns and gardens, is located in the Schmids Lake-East Carondelet area, which is south of Old Prairie du Pont Creek.

2.1.5 Surrounding Land Use and Population

2.1.5.1 Current Industrial Land Use

Heavy industry has located on the east bank of the Mississippi River between Cahokia and Alton, Illinois for nearly a century. Industrial activity peaked in the 1960s and industries have been closing ever since. Although heavy industry has shut down throughout the American Bottoms, Sauget Area 2 and the surrounding area is still highly industrialized. In addition to heavy industry, the area currently has warehouses, trucking companies, commercial facilities, bars, nightclubs, convenience stores and restaurants. Industrial facilities operating in the area are listed below:

West of Mississippi Avenue (Route 3)	
Cahokia Marine Services	Coal Bulk Storage and Transfer

Eagle Marine Industries	Barge Terminal and Fleeting
Phillips Pipe Line Company	Petroleum Bulk Storage and Transfer
Onyx Environmental Services	Hazardous Waste Treatment
Peavey/ConAgra	Bulk Grain Storage and Transfer
River City Landscape and Supply	Lawn and Garden Product Storage
Slay Terminals	Coal Bulk Storage and Transfer
St. Louis Grain Company	Bulk Grain Storage and Transfer
Union Electric	Electricity Distribution

East of Mississippi Avenue (Route 3)

Astaris	Phosphorous Pentasulfide Manufacturing
Big River Zinc	Zinc Refining
Cerro Copper	Copper Tubing Manufacturing
Ethyl Corporation	Petroleum Additives Manufacturing
Exxon/Mobil	Petroleum Bulk Storage and Transfer
Flexsys	Rubber Chemicals Manufacturing
Oxychem	Swimming Pool Chlorine Manufacturing
Solutia	Monochlorobenzene Production
Sterling Steel Castings	Steel Foundry

A number of petroleum, petroleum product and natural gas pipelines, operated by Explorer Pipeline Company, Marathon, Phillips Pipe Line Company, ExxonMobil and Laclede Gas, are located in the area.

2.1.5.2 Past Industrial Land Use

A number of industrial facilities have operated in the Sauget Area over the years, all of which are potential sources of groundwater contamination in the study area. These include the following:

Zinc smelter (now known as Big Rivers Zinc)	Began smelting operations in the early 1900's. Continues in operation today.
Petroleum additives business (now known as Ethyl Petroleum	Building originally constructed for the war effort during World War 1. Since that time has house various chemical manufacturing operations
Petroleum Refinery (now owned by Exxon Mobil)	Refinery erected in 1917 and operated until the early 1970's
T.J Moss (property now owned by Kerr McGee)	Began wood treating facility in about 1927 and operated at least through 1968.
Cerro Copper products	Began operations as a brass and copper

	tubing manufacturing facility in 1927. Continues in operation today.
Clayton Chemical	1962 began operations as a crude oil topping plant. In the mid '60's crude oil topping ceased and solvent reclamation began. The facility closed in the 1990's.
Darling Fertilizer	1922 plant operations began, plant closed down in 1967
Sterling Steel	Began operation of a steel foundry in 1922. Continues in operation today.
Midwest Rubber	1928 constructed a rubber reclaiming plant. The plant was closed in the 1990's
Trade Waste Incinerator	Began hazardous waste incinerator operations in 1980.
Phillips Pipeline Company	Began operations as a petroleum terminal facility and tank farm in 1930. Continues in operation today.

In addition to the above is Solutia's W.G. Krummrich plant, located east of Route 3, which produces primarily Monochlorobenzene today. However, it produced a wide variety of products in the past including: Adipic Acid, Alkylbenzene, Aroclors, Benzyl Chloride, Calcium Benzene Sulfonate, Caustic Soda, Chlorine, Chlorinated Cyanuric Acid, Chlorobenzenes, Chlorophenols, 2,4-D, Fatty Acid Chloride, Monochloroacetic Acid, Muriatic Acid, Nitric Acid, Nitric Cake, Nitroaniline, Nitrodiphenylamine, Nitrophenol, Phenol, Phosphoric Acid, Phosphorus Halides, Potash, Potassium Phenyl Acetate, Salt Cake, Santicizer-160, Santoflex, Santolube 393, Santomerse #1, Sulfuric Acid, 2,4,5-T, Tricresyl Phosphate and Zinc Chloride.

2.1.5.3 Residential Land Use

No residential land use is located immediately adjacent to or downgradient of Sites O, P, Q, R and S; the W.G. Krummrich plant and other industrial facilities in the Sauget area. Residential areas of Sauget and East St. Louis are separated from this area by other industries or undeveloped tracts of land. Limited residential areas exist approximately 3,000 feet to the northeast and southeast of these industrial facilities. Industrial areas exist approximately 2000 feet west of this area, across the Mississippi River, in the City of St. Louis, Missouri, with residential areas located further to the west.

2.1.5.4 Waste Disposal Land Use

Historically, Sauget Area 2 and its surroundings were used for waste disposal. Six closed landfills (Sauget Area 2 Sites P, Q and R and Sauget Area 1 Sites G, H and I), four closed sludge lagoons (Sauget Area 2 Site O), a closed tank-truck wash-water lagoon (Sauget Area 1 Site L) and a waste disposal site (Site S) associated with an abandoned solvent reclamation facility (Resource Recovery Group) are located in the Sauget area. Sauget Area 2 Sites O, P, Q, R and S are described above in Sections 2.1.2.1, 2.1.2.2, 2.1.2.3, 2.1.2.4 and 2.1.2.5, respectively; Sauget Area 1 Sites G, H, I and L are described below.

Site G - Site G is located south of Queeny Avenue, east of the Wiese Engineering facility (some wastes extend underneath the facility), and north of a cultivated field in the Village of Sauget. Creek Segment B of Dead Creek is located along the eastern boundary of the site. Site G is approximately 5 acres in size and was operated and served as a disposal area for oil, drums containing wastes, paper wastes, documents and lab equipment from sometime after 1940 to the late 1980s. Intermittent dumping continued until 1988, when most of the site was fenced pursuant to a USEPA removal action under CERCLA. Wastes located on the surface and/or in the subsurface of Site G spontaneously combusted and/or burned for long periods of time on several occasions prior to the second removal action conducted at the site by USEPA in 1995. This removal action involved the excavation of PCB, organics, metals, and dioxin contaminated soils on and surrounding Site G, solidification of open oil pits on the site, and covering part of the site (including the excavated contaminated soils) with a clean soil cap approximately 18 to 24 inches thick. Waste was removed up to the foundation of the Wiese Engineering facility, which is located west of the fenced portion of Site G. The fenced portion of the site is vegetated. Estimated volume of waste in Site G is 139,715 cubic yards.

Constituents detected in groundwater at Site G, as reported in the 2001 Solutia Report "Sauget Area 1 EE/CA and RI/FS Support Sampling Plan Data Report", include:

VOCs	SVOCS
Acetone	4-Chloroaniline
Benzene	

Chlorobenzene
1,2-Dichloroethylene
Ethylbenzene
Methylene Chloride
4-methyl-2-Pentanone
Tetrachloroethylene
Toluene
Trichloroethylene
Vinyl Chloride
Xylene

Metals and Inorganics

Arsenic
Barium
Beryllium
Copper
Chromium
Lead
Nickel
Zinc

1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,4-Trichlorobenzene

Phenol
2-Chlorophenol
2,4-Dichlorophenol
2,4,6-Trichlorophenol
Pentachlorophenol

2-Methylphenol
3/4-Methylphenol

bis(2-ethylhexyl)phthalate
di-n-Butylphthalate

Chrysene
Dibenzo(a,h)anthracene
Fluoranthene
Indeno(1,2,3-cd)pyrene
Naphthalene
Phenanthrene

Site H - Located south of Queeny Avenue, west of Falling Springs Road and west of the Metro Construction Company property in the Village of Sauget, Site H occupies approximately 5 acres of land. The southern boundary of Site H is located 400 feet south of the intersection of Nickell Avenue and Fallings Springs Road. Site H is connected to Site I under Queeny Avenue and together they were known to be part of the Sauget-Monsanto Landfill, which operated from approximately 1931 to 1957 [Note: Sauget used to be known as Monsanto until the name of the village was changed]. Site H is not currently being used and the property is graded and grass-covered.

Due to the physical connection to Site I, waste disposal at Site H was similar to that at Site I. Chemical wastes were disposed of here from approximately 1931 to 1957. Wastes included drums of solvents, other organics and inorganics, including PCBs, para-Nitroaniline, Chlorine, Phosphorous Pentasulfide, and Hydrofluosilic Acid. Municipal wastes were also reportedly disposed of at Site H. The estimated volume of waste in Site H is 168,432 cubic yards.

Constituents detected in groundwater at Site H, as reported in the 2001 Soutia Report "Sauget Area 1 EE/CA and RI/FS Support Sampling Plan Data Report", include:

VOCs

Acetone
Benzene
Chlorobenzene
Chloroform
1,2-Dichloroethylene
Ethylbenzene
Methylene Chloride
4-methyl-2-Pentanone
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
Trichloroethylene
Vinyl Chloride
Xylene

Metals and Inorganics

Arsenic
Barium
Cobalt
Chromium
Nickel
Vanadium
Zinc

SVOCS

4-Chloroaniline

1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,4-Trichlorobenzene
Hexachlorobenzene

Phenol
2-Chlorophenol
2,4-Dichlorophenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
Pentachlorophenol

2-Methylphenol

4,6-dinitro-2-Methylphenol

Naphthalene
2-Chloronaphthalene
2-Methylnaphthalene

bis(2-ethylhexyl)phthalate
di-n-Butylphthalate
di-n-Octylphthalate

Benzo(a)anthracene
Benzo((g,h,I)perylene
Benzo(a)pyrene
Fluorene
Indeno(1,2,3-cd)pyrene

Carbazole

Isophorone

Site I - Located north of Queeny Avenue, west of Falling Springs Road and south of the Alton & Southern Railroad in the Village of Sauget, Site I was estimated to occupy approximately 19 acres of land. Former Creek Segment A of Dead Creek borders Site I on the site's western side. The site is currently graded and covered with crushed stone and used for equipment and truck parking. Site I was originally used as a sand and gravel pit that received industrial and municipal wastes. Site I is connected to Site H (see above) under Queeny Avenue and together they were known to be part of the "Sauget-Monsanto Landfill." The landfill operated from approximately 1931 to 1957. Site I served as a disposal area for contaminated sediments from historic dredgings of Dead Creek Segment A.

This site accepted chemical wastes from approximately 1931 to the late 1950s. Municipal wastes were also disposed of in Site I. Though the causal agent could not be identified, five fence-installation contractors went to the hospital after a post-hole auger unexpectedly encountered a buried drum and brought some of its contents to the surface when the auger was removed. Four workers were released that day and a fifth was kept overnight for observation and released the next day. Site I is estimated to contain 680,827 cubic yards of contaminated wastes and fill material.

Constituents detected in groundwater at Site I, as reported in the 2001 Soutia Report "Sauget Area 1 EE/CA and RI/FS Support Sampling Plan Data Report", include:

VOCs

Benzene
Chlorobenzene
Ethylbenzene
Toluene
Xylene

Metals and Inorganics

Barium
Chromium
Cobalt
Copper
Lead
Molybdenum
Vanadium
Zinc

SVOCS

4-Chloroaniline

1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,4-Trichlorobenzene

Phenol
2-Chlorophenol
2,4-Dichlorophenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
Pentachlorophenol

2-Methylphenol
3/4-Methylphenol

n-Nitrosodiphenlyamine

bis(2-ethylhexyl)phthalate
Butylbenzylphthalate
di-n-Butylphthalate
di-n-Octylphthalate

Acenapthene
Benzo(a)anthracene
Benzo(k)fluoranthene
Benzo((g,h,i)perylene
Benzo(a)pyrene
Chrysene
Dibenzo(a,h)anthracene
Fluoranthene
Indeno(1,2,3-cd)pyrene
Napthalene

2-Methylnaphthalene

Site L - Site L is located immediately east of Dead Creek Segment-B and south of the Metro Construction Company property in the Village of Sauget. Site L is the former location of two surface impoundments used from approximately 1971 to 1981 for the disposal of wash water from truck cleaning operations. Drums, drum fragments and uncontained solid waste were discovered in Site L test trenches during the EE/CA investigation (O'Brien & Gere, 2000). This site is now covered by black cinders and is used for equipment storage. The volume of contaminated fill material in Site L is 18,069 cubic yards.

Constituents detected in groundwater at Site I, as reported in the 2001 Soutia Report "Sauget Area 1 EE/CA and RI/FS Support Sampling Plan Data Report", include:

Metals	VOCs
Arsenic	Benzene
Barium	Chlorobenzene
Cadmium	Chloroform
Chromium	Methylene Chloride\
Cobalt	Trichloroethylene
Copper	Xylene
Lead	
Molybdenum	**SVOCS**
Nickel	2-Chlorophenol
Selenium	2,4-Dichlorophenol
Vanadium	3/4-Methylphenol
Zinc	

2.1.5.5 Waste Treatment Land Use

Resource Recovery Group - The Resource Recovery Group solvent reclamation facility was shut down and subject to a USEPA emergency response action in 2001. From 1930 to 1962, this site and the area around it was used as a railroad repair yard, complete with roundhouse and terminal. In 1962, Joseph Reidy began operating a crude oil topping plant at the site. Products derived from this operation included white gas, distillate fuel oils, and residual bottoms materials. Oil tank bottoms and white gas were disposed to the ground on site. Clayton Chemical began solvent reclamation in the mid 1960s and continued until 1978. In 1983, IEPA modified the site's permit to allow acceptance and distillation of the following spent solvents:

- Spent halogentated-solvents including Tetrachloroethylene; Trichloroethylene; 1,1,1-Trichlroethane and Methylene Chloride;
- Spent nonhalogenated-solvents including Xylene, Acetone, Ethyl Acetate, Toluene and Methyl Ethyl Ketone; and
- Spent high-flash point, nonhalogenated solvents including Mineral Spirits, Glycol Ether and heavy Naptha.

All spent solvents were to have a minimum solvent content of 30 percent. F001, F002, F003 and F005 wastes and other sludges and still bottoms were excluded. Clayton Chemical was sold to Emerald Environmental in December 1993 and later renamed the Resource Recovery Group.

Onyx Environmental Services - An operating hazardous waste incineration facility, Onyx Environmental Services, is located in the area. Trade Waste Incineration (TWI), now Onyx Environmental Services, began by operating a hazardous waste incinerator on the Clayton Chemical property in 1980. Operations were relocated to their current site in 1983 after the property was purchased from the Illinois Central Gulf Railroad. Onyx currently operates three hazardous waste incinerators at this facility.

2.1.5.6 Wastewater Treatment Land Use

Two active wastewater treatment plants, the Village of Sauget PChem Plant and the American Bottoms Regional Treatment Facility, are located in this area. The Village of Sauget, Illinois owns and operates the Physical/Chemical Wastewater Treatment Plant (PChem Plant) and the American Bottoms Regional Wastewater Treatment Facility (ABRTF). The ABRTF, brought on line in 1986, provides both primary and secondary treatment for its regional service area. Activated sludge biological treatment is used for primary treatment and aerated lagoons with powdered activated carbon addition are used for secondary treatment. It also provides secondary treatment for effluent from the PChem Plant. The PChem Plant provides primary treatment for Village wastewater that consists primarily of industrial wastewater. ABRTF discharges treated effluent to the Mississippi River at River Mile 178 (NPDES Permit No. IL0065145). Treated effluent is discharged through a 100 ft. long multi-port diffuser located 100 feet from shore just north of Sauget Area 2 Site R.

2.1.6 Sensitive Ecosystems

2.1.6.1 Threatened and Endangered Species

There are two federally listed endangered species that can potentially be found at (or adjacent to) the Sauget Area Sites: 1) the Indiana bat (*Myotis sodalis*) and 2) the pallid sturgeon (Scaphirhynchus albus). One federally listed threatened species recorded in St. Clair County is the decurrent false aster (*Boltonia decurrens*). A federally listed species that is known to winter in the region and identified in the area is the bald eagle (*Haliaeetus leucocephalus*). The bald eagle was recently upgraded to threatened status from endangered by the USFWS.

Several state-listed bird species are likely to utilize the Sauget Area 2 Sites including the: black-crowned night heron (*Nycticorax nycticorax*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), great egret (*Casmerodius albus*) and pied-billed grebe (*Podilymbus podiceps*). The great egret and pied-billed grebe are listed as threatened by the State of Illinois; the other three species are listed as endangered by the State. Only the black-crowned night heron has been sighted within two miles of the Sites.

Additionally, there are 18 federally or state (either Illinois or Missouri) listed fish species that have been historically shown to be present in the main stem of the Mississippi River in the region of the Sites. Those species include:

Alabama shad	*Alosa alabamae*	highfin carpsucker	*Carpiodes velifer*
alligator gar	Atractosteus spatula	Iowa darter	*Etheostoma exile*
bigeye shiner	*Notropis boops*	lake sturgeon	*Acipenser fulvescens*
blacknose shiner	*Notropis heterolepis*	mooneye	*Hiodon tergisus*
brown bullhead	*Ameiurus nebulosus*	northern pike	*Esox lucius*
central mudminnow	*Umbra limi*	pallid sturgeon	*Scaphirhynchus albus*
crystal darter	*Crystallaria asprella*	sicklefin chub	*Macrhybopsis meeki*
flathead chub	*Platygobio gracilis*	sturgeon chub	*Macrhybopsis gelida*
greater redhorse	*Moxostoma valenciennesi*	trout-perch	*Percopsis omiscomaycus*

2.1.6.2 Sensitive Habitats

Sensitive habitats include those ecological systems that support endangered or threatened species (either federally or state listed) or support wetlands. Given the lack of endangered or threatened species that are expected to be found on the Sites, habitat to support these species is not expected to be present. A pair of bald eagles attempted to nest on the southern end of

Arsenal Island, south of the Sites, in 1993. While the pair failed in their first attempt, it is not know whether later attempts were successful. A nest was observed in 1996, but it did not appear to be in use.

A review of the National Wetland Inventory (NWI) map for the Sites, prepared by the U.S. Fish and Wildlife Service, indicates that a substantial portion of the Source Areas P and Q are categorized as wetlands. These wetlands are listed as palustrine wetlands, dominated by deciduous forests, shrub/scrub plant species, or emergent plant species. Palustrine wetlands are bounded by uplands or any other type of wetlands and may be situated shoreward of lakes, river channels or in floodplains. Shrubs are woody plant species ranging from 3 to 20 feet in height. Emergent plants are those species in which at least a portion of the foliage and all of the reproductive structures extend above the surface of any standing water. Typical of this type of plant include cattails (*Typha* sp.), common reed (*Phragmites australis*), rushes (*Juncus* sp.) and sedges (*Carex* sp.). Emergents are usually found in shallow water or on saturated soils.

2.1.7 Meteorology/Climatology

The National Climatic Data Center (NCDC) describes the areas' climate as modified continental, subject to four-season climate changes without the undue hardship of prolonged periods of extreme heat or high humidity. To the south is the warm, moist air of the Gulf of Mexico; and to the north, in Canada, is a region of cold air masses. The convergence of air masses from these sources, and the conflict on the frontal zones where they come together, produce a variety of weather conditions, none of which are likely to persist for any great length of time.

Winters are brisk and seldom severe. Records since 1870 show that the temperature drops to zero degrees Fahrenheit (0°F) or below on average two to three days per year. The area stays at or below 32°F for less than 25 days in most years. Average snowfall for the area is a little over 18 inches per winter season. Snowfall of an inch or more is received on five to ten days in most years. The long-term record for the St. Louis area (since 1870) indicates that temperatures of 90°F or higher occur on about 35 to 40 days per year, and extremely hot days of 100°F or more are expected no more than five days per year.

The normal annual precipitation for the area is slightly less than 34 inches. The winter months are the driest, with an average total of about six (6) inches of precipitation. The spring months of March through May are normally the wettest with normal precipitation of just under 10.5 inches.

2.2 Groundwater Fate and Transport

2.2.1 Groundwater Flow Direction

During low river stage conditions, groundwater at Sauget Area 2 flows from east to west and discharges to the Mississippi River, the natural discharge point for groundwater in the American Bottoms aquifer. For example, in October 2001 groundwater elevations in the Middle Hydrogeologic Unit were 394 ft MSL at Route 3 (Mississippi Avenue) and 389 ft. MSL at the downgradient limit of Site R when the average river elevation was 390 ft MSL. When flood stage occurs in the Mississippi River, flow reverses. For example, in November 1985 river stage was 32 to 33 feet above the USACE datum (low flow river stage is 5 to 7 feet above this datum). Groundwater elevation in the Middle Hydrogeologic Unit at the downgradient edge of Site R was 406 ft. MSL and 394 ft. MSL at Route 3. Under these conditions, groundwater flow was from west to east for a distance of approximately 4,500 feet.

A 1993 Geraghty & Miller report on groundwater flow conditions in the area from the W.G. Krummrich plant to Sauget Area 2 Site R is included in Volume II. Groundwater flow conditions were also modeled by Geraghty & Miller in 1993 and these results are included in Volume II.

2.2.2 Groundwater Flow Rate

Groundwater flow velocity is on the order of 0.02 feet per day (7 feet per year), 4 feet per day (1,500 feet per year) and 6 feet per day (2,200 feet per year), respectively, in the Shallow Hydrogeologic Unit, the Middle Hydrogeologic Unit and the Deep Hydrogeologic Unit. Geraghty & Miller estimated that 795,000 gallons per day (550 gallons per minute) of groundwater was discharging to surface water downgradient of Site R.

2.2.3 Contaminant Fate and Transport

Groundwater flow velocity is on the order of 0.02 feet per day (7 feet per year), 4 feet per day (1,500 feet per year) and 6 feet per day (2,200 feet per year), respectively, in the Shallow Hydrogeologic Unit, the Middle Hydrogeologic Unit and the Deep Hydrogeologic Unit. With groundwater flow rates of 4 to 6 feet per day, constituents migrating in the MHU and DHU could reach the Mississippi River in time periods as short as approximately 40 days and 25 days, respectively. Processes such as dispersion, dilution, biodegradation, adsorption, precipitation, etc. will retard or slow the movement of site-related constituents migrating toward the Mississippi River in the MHU and DHU. However, it is unlikely that these processes have much of an effect given the high groundwater flow velocities in the MHU and DHU and the short distance from Site R to the river.

2.2.4 Contaminant Characteristics

A wide-range of constituents is present in groundwater at the Sauget Area 2 Sites. Constituents mobile in the groundwater system at Sauget Area 2 include:

VOCs	SVOCs	
Acetone	Acenapthylene	Dimethylphenol
Benzene	Aniline	Di-n-butylphthalate
Bromoform	Benzo(a)pyrene	Di-n-octylphthalate
2-Butanone	Benzo(k)fluoranthene	Fluouranthene
Chlorobenzene	Benzoic Acid	Hexachlorocylopentadiene
Chloroethane	Benzyl Alcohol	MethylNaphthalene
Chloroform	Bis(2-choroethoxy)methane	Methylphenol
Dichloroethane	Bis(2-chloroethyl)ether	Naphthalene
Dichloroethylene	Bis(2-ethylhexyl)phthalate	Nitrobenzene
Ethyl Benzene	Bis(2-chloroisopropyl)ether	Nitrochlorobenzene
Methylene Chloride	Chloroaniline	Nitrodiphenylamine
4-methyl-2-Pentanone	4-chloro-3-methylphenol	Nitrophenol
Trichloroethane	Chlorophenol	n-Nitrosodiphenylamine
Trichloroethylene	Chrysene	Pentachlorophenol
Tetrachloroethane	Dichlorobenzene	Phenol
Toluene	Dichlorobenzidine	Pyrene
Vinyl Chloride	Dichlorophenol	Trichlorophenol
Xylenes		

Metals

Arsenic	Chromium	Nickel
Barium	Cobalt	Vanadium
Cadmium	Lead	Zinc

Estimated mass loading to the Mississippi downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area is 220,000 kg/yr (484,000 pounds per year) or 603 kg/day (1,327 pounds per day). This is lower than USEPA's estimate of 680,000 kg/year (1,496,000 pounds per year). Since the Agency did not provide the basis determining of mass loading in its November 14, 2001 Notification of Additional Work, it is not possible to reconcile the difference between these two estimates.

2.3 Previous Removal and Remedial Actions

2.3.1 Site O

In 1980, the Village of Sauget closed four clarifier sludge lagoons at Site O by stabilizing the sludge with lime and covering it with approximately two feet of clean, low-permeability soil. Currently, the lagoons are vegetated.

2.3.2 Site R

In 1979, Monsanto completed the installation of a clay cover on Site R to cover waste, limit infiltration through the landfill, and prevent direct contact with fill material. The cover's thickness ranges from 2 feet to approximately 8 feet. In 1985, Monsanto installed a 2,250-foot long rock revetment along the east bank of the Mississippi River adjacent to Site R. The purpose of the stabilization project was to prevent further erosion of the riverbank and thereby minimize potential for the release of waste material from the landfill. During the 1993 flood, Site R was flooded but the clay cap was not overtopped. No erosion of the riverbank or cap resulted from this flood.

On February 13, 1992, the State of Illinois and Monsanto signed a consent decree entered in St. Clair County Circuit Court requiring further remedial investigations and feasibility studies to be conducted by Monsanto on Site R. The results of the Remedial Investigation/Feasibility Study were submitted to Illinois EPA in 1994. Solutia made a good faith offer to the IEPA to install an engineered cap and a leachate recovery system in 1997.

2.3.3 Site Q

USEPA initiated a removal action at Site Q on October 18, 1999. The ERRS contractor began to excavate site wastes on October 26, 1999 from eight excavation areas of various sizes on approximately 25-acres of site property. Two waste streams were developed based upon analytical results of the separate waste piles: 1) a low-level PCB waste stream with soil concentrations less than 50 ppm) that was shipped via truck to the Milam Recycling and Disposal Facility located in East St. Louis, Illinois and 2) a PCB waste stream with soil/debris containing greatet than 50 ppm PCBs that was shipped via rail car to the Safety-Kleen Lone & Grassy Mountain facility, located in Waynoka, Oklahoma. One hundred sixty three trucks, each containing approximately 20 tons of low-level PCB waste, were shipped to the Milam disposal facility. One hundred forty one rail cars, each containing approximately 90 tons of PCB waste, were shipped to the Lone Mountain facility. Drums excavated on site were crushed and added to either waste stream. Excavated drums that were void of waste material were added to either PCB waste stream; drums that contained waste were added to the greater 50 ppm PCB waste stream.

On April 5, 2000, removal of site wastes was completed. Approximately 17,032 tons of waste and 3,271 drums were removed from the site. Due to limited resources and the amount of contamination, this removal action did not address all of the contaminants present on the site. As a result, municipal waste is visible on limited portions of the site.

2.4 Source, Nature and Extent of Contamination

In January and May 2000, Solutia collected groundwater samples from selected existing monitoring wells to determine the areal and vertical distribution of VOCs and SVOCs in groundwater between its W.G. Krummrich (WGK) plant and the Mississippi River. Total VOC and Total SVOC concentrations were plotted and contoured for the Shallow Hydrogeologic Unit (SHU), Middle Hydrogeologic Unit (MHU) and Deep Hydrogeologic Unit (DHU) and the results are presented in the following figures:

Figure 2-7	Total VOC Concentrations, Shallow Hydrogeologic Unit
Figure 2-8	Total VOC Concentrations, Middle Hydrogeologic Unit
Figure 2-9	Total VOC Concentrations, Deep Hydrogeologic Unit
Figure 2-10	Total SVOC Concentrations, Shallow Hydrogeologic Unit
Figure 2-11	Total SVOC Concentrations, Middle Hydrogeologic Unit
Figure 2-12	Total SVOC Concentrations, Deep Hydrogeologic Unit
Figure 2-13	Impact of Historical W.G. Krummrich Operations on Groundwater Quality

Based on these isoconcentration plots, VOCs and SVOCs are present in groundwater from the Mississippi River to the WGK plant. Three concentration highs are evident on Figures 2-7 to 2-12: 1) one at Sauget Area 2 Sites R and Q (Dog Leg) immediately adjacent to the Mississippi River, 2) another at the location of Sauget Area 2 Sites O and S and 3) a third at the W.G. Krummrich plant. A review of historical data for Sites O, Q, R and S and current data for the W.G. Krummrich plant indicates that these concentration highs are most likely due to the migration of leachate and/or liquid waste from the various industrial disposal sites and dissolution of DNAPL trapped on and in the aquifer matrix beneath these sites.

2.4.1 Site R and Site Q (Dog Leg) Area

VOCs and SVOCs detected at Site R are summarized below:

Constituents detected in groundwater at Site R include:

VOCs	SVOCs	
Acetone	Aniline	3-Methylphenol
Benzene	2-Chloroaniline	4-Methylphenol
Bromoform	3-Chloroaniline	2,4-Dimethylphenol
2-Butanone	4-Chloroaniline	4-chloro-3-Methylphenol
Chlorobenzene	2-Nitroaniline	
Chloroethane	4-Nitroaniline	4-Nitrophenol
Chloroform		

Chloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
Ethylbenzene
trans-1,2-Dichloroethene
Methylene Chloride
4-methyl-2-Pentanone
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
Trichloroethene
Vinyl Chloride

1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,4-Trichlorobenzene

Nitrobenzene
2-Nitrochlorobenzene
3-Nitrochlorobenzene

4-Nitrochlorobenzene

Phenol
2-Chorophenol
4-Chlorophenol
2,4-Dichlorophenol
2,4,6-Trichlorophenol

Naphthalene
2-ChloroNaphthalene

Benzoic Acid
Benzyl Alcohol
bis(2-chloroethoxy)Methane
bis(2-ethylhexyl)Phthalate
Chrysene
Fluoranthene
4-Nitrodiphenylamine
n-Nitrosodiphenyamine
Pyrene

Constituents detected in groundwater at Site Q include:

VOCs

Benzene
Chlorobenzene
1,2-Dichloroethane
2-Hexanone
4-methyl-2-Pentanone
Toluene

Metals and Inorganics

Arsenic

Cyanide

SVOCs

4-Chloroaniline

Phenol
2-Chlorophenol
2, 4-Dichlorophenol
2,4,6-Trichlorophenol
Pentachlorophenol

4-Methylphenol
2,4-Dimethylphenol

2-Nitroaniline

Acenaphthylene

Given the history of waste disposal at these sites, detected groundwater concentrations at these Sites are most probably the result of migration of leachate from the waste materials to and through the aquifer and the dissolution of DNAPL trapped on the aquifer matrix and/or pore spaces.

Groundwater data collected at Site R in January and May 2000, and presented in Figures 2-7 to 2-12, indicate that the maximum Total VOC and SVOC concentrations at Site R are 74,600 µg/l and 6,760,000 µg/l, respectively. Total VOC concentration highs in the SHU, MHU and DHU are located in the northern half, northern two thirds and the extreme northern end of Site R, respectively, while the Total SVOC concentration highs are located in the central portions of Site R for all three of these hydrogeologic units.

These January and May 2000 groundwater data indicate there is a distinct vertical stratification of Total VOC and Total SVOC concentrations at Site R with concentrations decreasing with depth:

	Total VOC Concentration (ppb)	Total SVOC Concentration (ppb)
Shallow Hydrogeologic Unit	74,600	6,760,000
Middle Hydrogeologic Unit	47,210	1,529,000
Deep Hydrogeologic Unit	1,950	34,800

This distinct vertical concentration gradient, with the highest detected concentrations in the upper portions of the saturated zone, indicates that the waste material and/or DNAPL in the SHU is still acting as source that impacts groundwater quality. As discussed in Section 2.2, constituents that enter the Middle Hydrogeologic and the Deep Hydrogeologic Unit can be transported to the Mississippi River in time periods as short as 25 to 40 days.

Total SVOC concentrations of 6,760,000 in the SHU and 1,529,000 in the MHU indicate that DNAPL is probably present in the aquifer. Dissolution of DNAPL coating the aquifer matrix or trapped in aquifer pore spaces will act as a long-term, continuous source of impacted groundwater.

Groundwater data collected during pre-design investigations performed in July 2001 to collect design information for a groundwater extraction system downgradient of Site R, the following vertical distribution of Total SVOCs was found at two potential extraction well locations at the downgradient boundary of Site R:

Depth Below Ground Surface (feet)	Total SVOC Concentrations (ppb)	
	Proposed Groundwater Extraction Well 1	Proposed Groundwater Extraction Well 2
Shallow Hydrogeologic Unit		
20	12	NS
30	1,042,800	146
40	NS	12,470
50	156,000	404,010
Middle Hydrogeologic Unit		
60	125,600	172,320
70	158,300	64,640
80	90,000	84,300
Deep Hydrogeologic Unit		
90	203,520	24,926
100	77,140	21,810 (2
110	107,400	
120	77,840 (1	

Notes: 1) Sample at termination depth of 116 ft BGS
2) Sample at termination depth of 98 ft BGS

Vertical stratification of SVOCs is also apparent from data collected at the location of Proposed Groundwater Extraction Well 2, with the highest concentrations in the Shallow Hydrogeologic Unit, lower concentrations in the Middle Hydrogeologic Unit and lowest in the Deep Hydrogeologic Unit. This vertical distribution pattern is different in Proposed Groundwater Extraction Well 1 where Total SVOC concentrations do not decrease with depth between the MHU and the DHU. While it is difficult to know with certainty the reason for this difference in vertical distribution between these two proposed well locations, it may be due to the presence of DNAPL at the bottom of aquifer. Proposed Groundwater Extraction Well 1 was located 650 feet south of the north end of Site R. As discussed above, Total VOC and SVOC highs in the SHU, MHU and DHU are located in the northern two thirds of Site R. With a history of both solid and liquid waste disposal that allegedly started at the north end of Site R and continued to the south, it seems reasonable to expect the presence of DNAPL beneath and downgradient of this portion of Site R.

2.4.2 Site O and Site S Area

Constituents detected in groundwater at Site O include:

VOCs	SVOCs	Metals
Benzene	4-Chloroaniline	Arsenic
2-Butanone	1,2-Dichlorobenzene	Cadmium
Chlorobenzene	1,4-Dichlorobenzene	Lead
trans-1,2-Dichloroethene	4-Methylphenol	
Methylene Chloride	Phenol	
4-methyl-2-Pentanone		
1,1,2,2-Tetrachoroethane		
Tetrachloroethene		
Toluene		
Trichloroethene		

No groundwater data is available for Site S.

The groundwater concentration highs at the Site O and Site S area are not as apparent on Figures 2-7 through 2-12 as they are on Figures 2-25 to 2-28. Therefore, the following discussion is based on the data shown on Figures 2-25 to 2-28 which were compiled by Ecology and Environment and included in the 1998 Sauget Area 2 Data Tables/Maps Report. These maps, which are listed below, do not give actual concentrations but do show where concentrations highs are located.

Figure 2-25	Total VOC Concentrations, Shallow Wells
Figure 2-26	Total VOC Concentrations, Intermediate/Deep Wells
Figure 2-27	Total BNA Concentrations, Shallow Wells
Figure 2-28	Total BNA Concentrations, Intermediate/Deep Wells

In the Shallow Hydrogeologic Unit, there are two Total VOC concentration highs: 1) the western half of Site O and 2) downgradient of the Village of Sauget PChem Plant. There is only one Total VOC concentration high in the Middle/Deep Hydrogeologic Unit and it is located downgradient of the PChem Plant. Total BNA concentrations highs are located in the same areas in both the Shallow and the Middle/Deep Hydrogeologic Units.

2.4.3 Sauget Industrial Facilities

The Sauget area has been home to numerous industrial facilities over the years. While the nature and extent of contamination at those facilities, and their impact on groundwater in the area included in this Focused Feasiblity Study, is currently unknown, impacted groundwater is expected to be present at most if not all of these facilities. Constituents mobile in groundwater at the W.G. Krummrich plant have been studied. The following have been found in concentrations higher than the IEPA Tiered Approach to Cleanup Objectives (TACO) Tier 1 Industrial Criteria, are listed below:

VOCs	SVOCs	
Benzene	Chloroaniline	Nitrobiphenyl
Chlorobenzene	Chlorophenol	Nitrophenol
1,2-Dichloroethene	Dichlorobenzene	Pentachlorophenol
Ethylbenzene	Dichlorophenol	Phenol
Methyl Isobutyl Ketone	Naphthalene	Trichlorobenzene
Methylene Chloride	Nitroaniline	Trichlorophenol
Toluene	Nitrobenzene	
1,1,1-Trichloroethane		
Xylene		
Vinyl Chloride		

2.5 Analytical Data

2.5.1 Mississippi River

2.5.1.1 ABRTF Aquatic Habitat Assessment

In 1990, the Advent Group of Brentwood, Tennessee completed an aquatic habitat assessment in the Mississippi River for the American Bottoms Regional Wastewater Treatment Facility (Aquatic Habitat Assessment, Mississippi River near Sauget, Illinois, March 1990). This study was performed to examine the aquatic habitat and aquatic macroinvertebrate populations in the area downstream of a proposed multi-port diffuser.

The American Bottoms Regional Wastewater Treatment Facility (American Bottoms) is located in Sauget, Illinois. The facility receives both industrial and municipal wastes for physical and biological treatment prior to discharge of the treated effluent. The facility has a National

Pollutant Discharge Elimination System (NPDES) Permit to discharge these treated effluents into the Mississippi River at Mississippi River Mile (MRM) 178.2. A multiport high-rate diffuser has been designed to provide best engineering technology for dispersion of the effluent in the Mississippi River. The purpose of this study was to examine the aquatic habitat in the Mississippi River downstream from the proposed diffuser location. This assessment was developed using information in EPA's Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses.

Physical characteristics of the water body are the primary influence in determining aquatic habitat. These physical factors include flow (depth and velocity), temperature, substrate composition, suspended solids, and structure. Examples of structure or cover include rocks, rip-rap, logs, brush, vegetation (in-stream or riparian), roots, snags, pools, shadows, barge anchoring cells, etc. Additional physical/chemical factors such as turbidity, hardness, pH and the dissolved solids concentration can also affect habitat suitability. In addition to examining chemical/physical characteristics of the area, aquatic macroinvertebrates were examined to provide baseline information on the macroinvertebrate populations present. The study area ranged from approximately 100 ft upstream from the existing outfall to 2,000 ft downstream. The study was performed during the week of January 8, 1990.

Structure was visually surveyed and recorded during the field study. The projected path of the plume from the proposed diffuser based on modeling projections and River currents is shown in Figure 2-14. A visual summary of the habitat observations is presented in Figure 2-15. The shoreline immediately upstream (50 ft) from the outfall to about 600 ft downstream consisted primarily of sand, with rip-rap located along the shore at the outfall. From 600 to 1,000 ft downstream, the shoreline was predominantly rip-rap, with some sand. An exposed "sunken" barge was located beginning about 1,300 ft and extending to about 1,500 ft downstream, laying parallel to the shore. An old pier or "wing dam" is located at about 1,500 ft downstream. This wing dam has a number of old wooden pilings ranging to about 1 to 3 ft in height. During the field study, the wing dam was exposed (extended above the water line) for about 300 ft from shore. Upstream of the wing dam, the structure consists of five barge mooring cells. Two of the cells were upstream of the outfall. The three remaining cells were located approximately 200 ft from shore at about 0 to 300 ft downstream from the discharge. None of the potential structure identified was expected to be in the direct influence of the mixing zone.

Particle size analysis of substrate samples indicated the bottom of the river consisted primarily of fine to coarse sand, with some silt in the near-shore areas. A notable lack of benthic invertebrates was indicated. In all substrate samples examined in the field or laboratory, only a single chironomid, two oligochaetes, and a snail (Family Physidae) were observed. No additional quantitative analysis was performed on these samples. A large number of caddis fly (Tricoptera) cases were observed along the wind dam and attached to rip-rap along the shoreline both upstream and downstream from the outfall. Organisms collected from this area were subsequently identified to be Hydropsyche orris, or Hydropsyche bidens. These species are associated with large rivers and appear to be able to survive siltation better than most Hydropsyche species. Both are often collected where there is a high silt load and high concentration of suspended organic substrates. The individual larval retreats and pupal cases at times stack on top of one another. Pupal cases are constructed predominantly of secreted substances with sand grains attached. The case type and stacking characteristics were observed at the Sauget site at the wing dam. Table 2-1 summarized those organisms collected and identified during the field study.

The proposed placement of the diffuser was in an area that will not adversely effect aquatic habitat. Title 35, Subtitle C, Chapter I, Section 301.102 of the Illinois Administrative Code (IAC) stipulated the following limitations with regard to aquatic habitat in any receiving waters in which a mixing zone is allowed:

- Mixing is not allowed in waters which include a tributary stream entrance if such mixing occludes the tributary mouth or otherwise restricts the movement of aquatic life into or out of the tributary;
- Mixing is not allowed in waters adjacent to bathing, bank fishing areas, boat ramps or dockages or any other public access area; and
- Mixing is not allowed in waters containing mussel beds, endangered species habitat, fish spawning areas, areas of important aquatic life habitat, or any other natural features vital to the well being of aquatic life in such a manner that the maintenance of aquatic life in the body of water as a whole would be adversely affected.

No tributary streams entered the Mississippi River within 2,000 ft downstream from the ABRWT facility outfall. In addition, no public bathing, bank fishing areas, boat ramps or dockages occur within 2,000 ft downstream from the facility.

There were no mussel beds evident during the habitat assessment study. The substrate in the area of the project diffuser mixing plume consisted entirely of sand. This type of substrate, particularly when located in an off-shore area with no structure or cover, is not a productive biological habitat. In addition, only four benthic macroinvertebrate specimens were observed in 45 sediment samples collected, supporting evidence that the substrate was poor habitat for benthic organisms. None of the macroinvertebrates collected were threatened or endangered species.

A submerged log upstream from the present outfall, rip-rap along the shore, five barge cells, and the wing dam located about 1,500 ft downstream were found to be the only significant habitat in this area. These structures are in areas outside the proposed mixing zone.

Habitat characteristics observed during the field investigation in the area immediately upstream and downstream of the proposed diffuser are summarized in Table 2-2.

This assessment concluded that the maintenance of aquatic life in the river as a whole would not be adversely affected by the ABRTF diffuser because of:

- Depths, velocities, substrate, and lack of structure in the projected diffuser plume, and;
- Diffuser design preventing organisms from entering the area of immediate mixing.

2.5.1.2 ABRTF Biological Assessment

The Advent Group conducted another river study for the American Bottoms Regional Wastewater Treatment Facility in 1996 (Biological Assessment of the Mississippi River Near

Sauget, Illinois, April 1996). This study was conducted for the Village of Sauget in order to meet the requirements of a 1992 Consent Decree with USEPA and IEPA. ABRTF was required to conduct a biological study in the area affected by or within the plume of the ABRTF discharge as well as the near shore and wing dam areas. As outlined in the Consent Decree, the biological study was to:

- Examine fish populations present in the study area during one sampling event between July and October in 1994 or 1995:
- Characterize the substrate on the downstream side of the wing dam and southward along the shore between a distance of 1,600 ft and 2,000 ft from the diffuser; and
- Evaluate the macroinvertebrate community within the plume of the ABRTF discharge.

This assessment of water quality and biological conditions was conducted from September 19, 1994 to September 21, 1994 in accordance with a work plan approved by USEPA and IEPA. Specific objectives of the study were to:

- Collect 72 sediment samples at 18 locations for use in examining the macroinvertebrate community and characterizing the habitat and substrate present just upstream of the diffuser and on the downstream side of the wing dam;
- Characterize aquatic habitats present south along the shore between a distance of 1,600 and 2,000 ft from the diffuser;
- Characterize and describe the fish populations present in the near shore and wing dam sections of the diffuser study area and with 2,000 ft downstream of the diffuser; and
- Collect various physical and chemical water quality measurements.

In accordance with the Consent Decree, sampling transects were established approximately 100 ft upstream of the diffuser and at 1,600; 1,700; 1,800; 1,900 and 2,000 ft downstream of the diffuser (Figures 2-16, 2-17 and 2-18). Sampling stations were located 30 ft, 150 ft and 300 ft from the left edge of water on each transect. Water velocity readings taken at 0.2, 0.6 and 0.8 of total water depth indicated velocity ranges from 0 to 2.02 ft/sec in the study area. Highest water velocities occurred at sampling stations located 300 ft offshore. Velocity values at a given sampling station were did not vary much with depth. Temperature, dissolved oxygen, conductivity and pH showed little variability with water depth or distance from shore. Relatively low Secchi disk values of 8 to 13 inches reflect the high turbidity and concomitant poor light penetration into study area waters.

Based on the results of conductivity data, effluent was present in the area of the wing dam during the study. Conductivity increased by approximately 30 to 130 micromhos/cm downstream of the discharge. Except for conductivity, no differences were observed in general water quality characteristics of waters upstream and downstream of the effluent discharge.

Sediment sampling indicated that highly diverse bottom substrate is present throughout the study area ranging from fine, silty materials to rock/cobble substrates (Tables 2-3 and 2-4). Sand was the predominant substrate. Although the bottom substrate varied considerably, from essentially 100% sand to 100% gravel at the sampling stations, substrate upstream of the wing dam, especially in near-shore areas, was predominantly sand. Based on visual observations, some sediments were "mucky" and "silty" in nature. These sediments were generally present in areas of very low water velocity where fine materials with apparently higher levels of organic carbon were accumulated. Sediments at many locations consisted primarily of sand (over 90%). Although not present in many near-shore areas, except immediately adjacent to the rip-rap bank, gravel was a primary component of the substrate at locations further offshore.

Changes in bottom topography were observed throughout the study area but the wing dam and the sunken barges were the only notable habitat. They were also the only notable cover in the study area that would attract fish. The cover present at the rocky wing dam extending above the water's surface consists of the wing dam and wooden posts along its downstream side. Rip-rap was present in some areas of the wing dam while other bottom substrates in the area are almost entirely composed of sand. Still other areas of the wing dam possess small areas of rock and cobble substrate.

At the time of the study, an area of shallow water, approximately one foot deep, was present between the wing dam and the left edge of water. This area consisted of small riffles resulting from water running over the rocky bottom substrate. Good benthic-macroinvertebrate habitat was provided by the many crevices and areas of loose rock which created shelter as well as dwelling and feeding sites for such organisms. Water velocity in this area averaged 1.93 ft/sec while average water velocities around the wing dam ranged from 0.02 to 2.62 ft/sec.

The changes in bottom composition, presence of above water structures and the steep depth and current gradients caused by the wing dam provide the best structure and cover for fish in the entire study area. Additionally, a sunken barge present upstream, and approximately 100 ft farther from the left edge of water that the wing dam, provides additional cover.

Organisms primarily represented at the sampling stations were the aquatic life stages of various insects (midges, caddis flies, may flies, beetles, dragon flies and damsel flies), although aquatic worms (Oligochaetes), snails (Gastropods) and clams (Pelycepods) were also present. Insects dominated the macroinvertebrate fauna both upstream and downstream of the discharge with midges and caddis flies comprising the majority of the organisms at most locations. Caddis fly and may fly species, organisms considered by USEPA to be intolerant to degraded water quality, were collected from sites downstream of the effluent discharge.

More taxa and a higher abundance of macroinvertebrates were observed in this study than in 1990. However, macroinvertebrate richness and abundance were low in the near-shore area of the wing dam as well as in near-shore areas upstream of the effluent discharge. The relatively low richness and abundance of macroinvertebrates in good-quality habitats likely reflects the nature of benthic communities in big-river systems such as the Mississippi River near St. Louis. Both the abundance and richness of macroinvertebrates generally increased with increased distance from shore along transects upstream and downstream of the discharge. This likely reflects improved habitat quality with distance from the shore as increased proportions of gravel were often found in samples collected farther from shore. Similar macroinvertebrates were observed in near-shore areas upstream and downstream of the discharge when benthic substrate composition was similar. The highest abundance and diversity of organisms were observed at stations located approximately 300 ft from shore and downstream of the effluent discharge.

In summary, macroinvertebrate data indicated that a variety of organisms were present throughout the study area. The macroinvertebrate community was generally dominated by insects although clams, snails and aquatic worms were also present. No clear patterns in species composition or numbers were evident for samples collected from upstream as compared to downstream of the discharge. However, higher richness of individuals as well as taxa were present in samples collected from sites 300 ft from shore as opposed to sites 30 ft or 150 ft from shore. This is likely due to the higher proportions of gravel composing the substrate at locations 300 ft from shore. Higher numbers of individuals and taxa were present in samples collected downstream of the outfall as opposed to upstream of the outfall. These differences are also likely due to habitat composition. The presence of the wing dam and the associated rocks and gravel and changes in bottom substrate improved the quality of benthic habitat. Organisms considered to indicate "acceptable" water quality were present in samples collected from upstream and downstream of the effluent discharge. Overall, no deleterious impacts to macroinvertebrates appeared to be occurring as a result of the effluent discharge.

Overall, with the exception of changes in bottom topography, the fish-attracting habitat upstream of the wing dam was quite limited and the bottom appears to be barren and primarily sand. However, water quality conditions in this area appear to be quite suitable for habitation by fish. A total of 12 different fish species were collected in the study area. In order of abundance they were:

Common Name	Species Name	Number of Individuals
Gizzard Shad	Dorosoma cepedianum	37
Common Carp	Cyprinus carpo	31
White Bass	Morone chrysops	19
River Carp Sucker	Carpiodes carpio	13
Freshwater Drum	Aplodinotus grunniens	6
Bigmouth Buffalo	Ictiobus cyprinellus	5
Smallmouth Buffalo	Ictiobus bubalus	3
Flathead Catfish	Pylodictus olivaris	2
Goldeye	Hiodon alosoides	2
Shorthead Redhorse	Moxostoma macrolepitodum	1
Bluegill	Lepomis marcrochirus	1
Skipjack Herring	Alosa chrysochloris	1
	Total	121

All of these species are typical of what might be found in the Mississippi River basin and similar big-river systems. Common carp are considered to be a "rough" fish, tolerant of compromised water quality. All of the other fish present in the study area are generally considered "facultative" in terms of water quality indicators, i.e. they do not necessarily typify impacted or high-quality waters. Exceptions to this might be: 1) the shorthead redhorse which "is probably quite sensitive to siltation and pollution" (Miller and Robinson, 1973, The Fishes of Oklahoma, University of Oklahoma Press, Stillwater, Oklahoma) and 2) the goldeye which is considered to be intolerant (USEPA, 1989, Rapid Bioassessment Protocols for Use in Streams and Rivers - Benthic Macroinvertebrates and Fish, EPA/444/4-89-001, USEPA Office of Water, Washington, DC). Overall, the species present in the study area represent a good mixture of various types of fish representative of varying water quality and habitat.

The most abundant fish present, the gizzard shad, is a planktivorous, filter-feeding fish found in large rivers and reservoirs. This fish could not be considered indicative of compromised water quality. Gizzard shad are commonly found in high-quality fisheries typical of reservoirs managed for sport fishing. Although the common carp, the second most abundant fish observed, is typically considered to be a quite "tolerant" fish this is based primarily on its tolerance to organic enrichment and associated low dissolved oxygen concentrations. Markedly depressed dissolved oxygen conditions were not observed during the study. The presence of carp and other "rough" fish, such as the river carpsucker and buffalo species, is not an indication of "impacted" condition given the variety of other fish present. For example, white bass (the third most abundant fish observed), bluegill, flathead catfish and, to a lesser extent, the freshwater drum are considered "sport fish" and are often found in waters inhabited by other "top level" carnivorous sport fish.

USEPA (1989) considers the fish found in the study area to be indicative of the following types of water quality when found in the Midwest:

Type of Fish	Type of Water Quality
Common Carp	Tolerant
Goldeye	Intolerant
Bluegill	Intermediate
Bigmouth Buffalo	Intermediate

Smallmouth Buffalo	Intermediate
Shorthead Redhorse	Intermediate
Skipjack Herring	Intermediate
Gizzard Shad	Intermediate
River Carpsucker	Intermediate
Flathead Catfish	Intermediate
White Bass	Intermediate

A good mixture of fish was found in the study area in terms of their ecological niche and status. For example, the white bass and flathead catfish are piscivorous as adults and opportunistic carnivores (insects and fish) at earlier life stages. The bluegill, goldeye, skipjack and freshwater drum are opportunistic carnivores throughout their life cycles. As adults, drum tend to feed more on bottom-dwelling mollusks and insects and skipjack tend to feed more on fish. Shorthead redhorse are primarily bottom-feeding carnivores. Bigmouth buffalo are primarily filter feeders and bottom-feeding carnivores. Gizzard shad are filter-feeders eating primarily plankton and detritus filtered from the water. Carp, carpsucker and smallmouth buffalo are primarily bottom-feeding omnivores eating plants, animal flesh and detritus.

A range of condition factors was observed for fish collected in the study area. Most were at or above the value of 1.0 considered typical for fish in good health (Carlander, 1969 and 1977, Handbook of Freshwater Fishery Biology - Volumes I and II, Iowa State University, Ames, Iowa). Average condition factor values were above 1.0 for all species for which three or more individuals were collected. Of the 121 fish collected, only two had anomalies. One white bass was missing its left opercle (gill cover) and one goldeye had a head sore. Neither of these two anomalies can be related to the effluent discharge because of the highly mobile nature of fish.

No impacts were evident to the fish community present downstream of the outfall at the time of the study. A variety of fish representing a range of trophic levels and niches were observed. The fish present were primarily indicative of "intermediate" water quality, although one species of "tolerant" as well as one species of "intolerant" fish were observed. The low number of anomalies (2 of 121 specimens) and typical condition factors observed for fish in the area downstream of the outfall also indicated a relatively healthy fish population.

The overall conclusion from this biological assessment was that no deleterious impacts to fish or macroinvertebrate communities resulted from the effluent discharge.

2.5.1.3 Solutia Surface Water Sampling Plan

Work Plan - An Administrative Order on Consent (USEPA Docket Number R8H-5-00-003) requires Solutia to complete activities necessary to identify and define the nature and extent of releases of hazardous waste and/or hazardous constituents at or from the W.G. Krummrich Facility. This May 3, 2000 AOC also requires Solutia to prepare a Description of Current Conditions Report, a Groundwater Environmental Indicators Report (EIR) and a Current Human Exposure Environmental Indicators Report. Originally, the AOC required that the Groundwater EIR must be completed by January 1, 2002. USEPA extended this deadline in December 2001. A Current Human Exposures EIR must be completed by January 1, 2004. Solutia must also propose, by June 1, 2004, final corrective measures necessary to protect human health and the environment for all current and future unacceptable risks due to releases of hazardous waste or hazardous constituents at or from the Facility.

Solutia submitted a Description of Current Conditions Report, which included a Site Sampling Plan, to USEPA on August 1, 2000. Surface Water, Groundwater and Soil Sampling Plans were included in the Site Sampling Plan. The Surface Water Sampling Plan was implemented in October 2000 and current plans call for completing the Groundwater Sampling Plan in 2001 and the Soil Sampling Plan in 2003.

Surface water, sediment and fish sampling were conducted in the Mississippi River in October 2000 to determine the impact, if any, of groundwater discharge from the W.G. Krummrich facility. Surface water and sediment samples were collected in the Mississippi River at three locations: 1) upstream of the plume discharge area, 2) the plume discharge area and 3) downstream of the plume discharge area.

Samples were analyzed to determine the concentration of VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin in these environmental media. In addition, benthic community structure was evaluated to provide data for sediment triad evaluation. Bioassays were conducted on surface water and sediment samples to determine the toxicity, if any, of these environmental media to sensitive organisms. Fish were sampled in the plume discharge area and upstream and downstream of this discharge to determine the impact, if any, of groundwater discharge on higher trophic level organisms. Information collected as part of the Surface Water Sampling Plan will be used in a Ecological Risk Assessment, a Human Health Risk Assessment, a Groundwater Environmental Indicators Report and a Current Human Exposure Environmental Indicators Report.

Reconnaissance Survey - A reconnaissance survey was conducted in September 2000 to characterize river bottom substrates and identify surface water, sediment and fish sampling locations. During this reconnaissance survey, conducted in conjunction with USEPA, sediment samples were collected in the area of plume discharge along three transects running from the bank toward center of the river. Analytical results are summarized below:

	Distance from Bank, feet								
Total VOCs, ppb	50	200	300	400	500	600	700	1000	1400
North Transect	644	NS	854	ND	NS	NS	ND	ND	ND
Center Transect	1300	ND	NS	NS	ND	NS	NS	NS	NS
South Transect	45	NS	473	NS	NS	1	NS	NS	NS

River Sampling - These sediment sample analyses indicated that sampling transects located 300 ft from the riverbank would be within the area of plume discharge. Therefore, surface water samples were collected along three transects running parallel to the bank and located 50, 150 and 300 ft from the riverbank. Three sampling stations were located on each transect resulting in nine sampling stations within the plume discharge area. One sampling station was located at the center point of each transect. Another sampling station was located half way between the center station and the upstream end of each transect. A third sampling station was located half way between the center station and the downstream end of each transect.

At each sampling station, one surface water sample was collected and analyzed for VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin to determine the concentration of these constituents in surface water. Samples were collected just above the sediment/surface water interface. Bioassays, using Cerodaphnia and Fat Head Minnows, were performed on each surface water sample to determine surface water toxicity. In addition, one sediment sample was collected at each sampling station and analyzed for VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin to determine the concentration of these constituents in sediments. Bioassays, using Hyallela and Fat Head Minnows, were performed on each sediment sample to determine sediment toxicity. Benthic community structure was determined using three grab samples collected at selected locations within each sampling area. Since the dominant river bottom substrate is sand, benthic communities were expected to be limited.

Sediment toxicity testing was performed using USEPA approved methods, specifically "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates (EPA/600/R-99/064). Hyallela azteca and Chironomous tentans were originally proposed to USEPA Region 5 RCRA as the sediment toxicity test organisms. In response to an Agency comment on the proposed test organisms, fathead minnows were used instead of Chironomous tentans so that sediment toxicity testing could be performed on one benthic organism (Hyallela azteca) and one lotic organism (fathead minnow). This change in test organisms was considered appropriate because sand is the dominant substrate in the plume discharge area. Under these conditions, testing two benthic organisms (Hyallela azteca and Chironomous tentans) would produce less useful information that testing one benthic organism (Hyallela azteca) and one lotic organism (fathead minnow). Substituting a lotic organism for a benthic organism allowed direct assessment of the effects of sediment in the plume discharge area on higher trophic level organisms.

Three composite samples of each target fish species were collected in each sampling area to determine the impact of groundwater discharge to surface water on bottom feeder, forager and predator fish. A food source approach was used to select fish for analysis:

Food Source	Fish	Trophic Level	Endpoint Organism
Omnivore	Channel Catfish	Bottom Feeder	Channel Catfish
Plankton	Shad (Large)	Forager	Osprey
	Shad (Small)		Heron
Omnivore	White Bass, Buffalo	Predator	Recreational Fisher

A fourth fish sample was collected in order to provide fillet data for the Human Health Risk Assessment. Fish tissue samples were analyzed for VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin. Three to five fish were collected for each composite. Fish stomach contents were examined and recorded to document food sources.

One local area of soft bottom sediment was observed during the September 2000 reconnaissance survey at a wing wall downstream of the site. One soft bottom sample was collected in this area and analyzed for VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin. Bioassays, using Hyallela and Fat Head Minnows, were performed on this sediment sample to determine sediment toxicity. Three grab samples were collected at this sampling station to determine benthic community structure. One surface water sample was collected at this location and analyzed for VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin. This water sample was collected just above the sediment/surface water interface. Bioassays, using Cerodaphnia and Fat Head Minnows, were performed on this surface water sample to determine surface water toxicity.

To provide a basis for comparison, one soft bottom sample was collected upstream of the site and analyzed for VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin. Bioassays, using Hyallela and Fat Head Minnows, were performed on this sediment sample to determine sediment toxicity. Benthic community structure were determined by collecting and evaluating three grab samples at this sampling station. One surface water sample was collected at this location and analyzed for VOCs, SVOCs, Pesticides, Herbicides, PCBs and Dioxin. This water sample was collected just above the sediment/surface water interface. Bioassays, using Cerodaphnia and Fat Head Minnows, were performed on this surface water sample to determine surface water toxicity.

Sediment, surface water and fish tissue analytical result summaries and a summary of sediment and surface water toxicity testing are included in Tables 2-18, 2-19, 2-20, 2-21, 2-22 and 2-23. Sampling locations are shown on Figures 2-19, 2-20, 21-21 and 2-22. These analytical data were used to prepare the Ecological Risk Assessment summarized in Section 2.6.2.3. Data quality, split sample results and data usability are discussed in the following sections.

Data Quality - Sediment, surface water and fish tissue samples were collected and analyzed using procedures, protocols and methods included in the "RCRA Quality Assurance Project Plan for the Ecological Risk Assessment at the W.G. Krummrich Facility, Sauget, Illinois" submitted to USEPA Region 5 RCRA on August 7, 2000, revised in accordance with Agency comments and issued in final form November 15, 2000. An outline of this QAPP is given below and the Surface Water Sampling Plan, Field Sampling Plan and Quality Assurance Project Plan are included in Volume 4A of this Focused Feasibility Study:

1.0 Project Description

1.1 Introduction
1.2 Site Facility Description, Historical Data and Current Status
1.3 Project Objectives and Decision Statements
1.4 Sampling Plan Design and Rationale
1.5 Target Parameters, Rationale, Media and Frequency
1.6 Project Schedule

2.0 Project Organization and Responsibility

2.1 RCRA Project Manager
2.2 Facility Program Manager
2.3 Ecological Project Manager and Field Leader for Ecological Risk Assessment
2.4 Ecological QA Chemists
2.5 Technical Staff for the Ecological Risk Assessment Activities
2.6 Laboratory Quality Assurance Officers and Project Managers
2.7 Data Validation Contractor

3.0 Quality Assurance Objectives for Measurement Criteria

3.1 Level of Quality Control Effort
3.2 Precision
3.3 Accuracy
3.4 Sensitivity - Reporting Limit Requirements
3.5 Completeness
3.6 Representativeness
3.7 Comparability
3.8 Decision Rules

4.0 Ecological Risk Assessment Field Sampling Plan

4.1 Study Area
4.2 Field Sampling Rationale and Sampling Locations
4.3 Surface Water Sampling
4.4 Sediment Sampling

13.0 Corrective Actions

13.1 Field Corrective Actions
13.2 Laboratory Corrective Actions
13.3 Data Validation and Data Assessment Corrective Actions

14.0 Quality Assurance Reports to Management

Sediment and surface water toxicity testing were performed using USEPA approved methods, specifically "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms (EPA/600/4-91-002)" and "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates (EPA/600/R-99/064).

Split Samples - As a further verification of data quality, analytical results for split samples collected by USEPA at sediment sampling locations PDA-2, PDA-5 and PDA-8 were compared to Solutia's analytical results:

	PDA-2		PDA-5		PDA-8	
	USEPA	Solutia	USEPA	Solutia	USEPA	Solutia
VOCs (ug/kg)						
Chlorobenzene	10,000	7,200	450	1,800	700	1,600
1,2-Dichloroethane	ND(1,100)	ND(2.2)	110J	ND(0.92)	41J	ND(1)
Toluene	12,000	7,800	140J	840	ND	4.6
Xylenes, Total	ND(1,100)	82	120J	710	ND(340)	8.5
SVOCs (ug/kg)						
Aniline	210J	NA	3,900J	NA	ND(410)	NA
4-Chloroaniline	720	2,200	3,300	ND(410)	ND(410)	180J
2-Chlorophenol	ND(580)	ND(300)	400J	ND(210)	ND(410)	ND(210)
1,2-Dichlorobenzene	120J	110J	ND(780)	ND(210)	ND(410)	ND(210)
1,4-Dichlorobenzene	390J	ND(300)	ND(780)	ND(210)	ND(410)	ND(210)
2,4-Dichlorophenol	ND(580)	ND(300)	610J	ND(210)	ND(410)	ND(210)
3-Methylphenol	95J	800	ND(780)	ND(210)	ND(410)	ND(210)
Phenol	ND(580)	ND(300)	3,200J	ND(210)	ND(410)	ND(210)
Pesticides (ug/kg)						
delta-BHC	ND(6)	ND(1.5J)	44J	ND(1.1)	5.1J	ND(1)
Chlorobenzilate	ND(120)	NA	21J	NA	ND(41)	NA
4,4-DDD	ND(6)	ND(5.8J)	14	ND(1.6)	ND(2.1)	ND(4)
PCBs (ug/kg)	ND(58)	ND(30)	84J	ND(21)	ND(41)	ND(21)

Herbicides (ug/kg)						
2,4-D	ND(140)	ND(14)	790	2,300	ND(99)	ND(10)

ND = Non Detect
NA = Not Analyzed

Data Usability - New Environmental Horizons, an independent third party, validated the surface water, sediment and fish tissue analytical data and prepared the following Data Usability Reports:

- **Data Usability Review, Organic Analysis by Methods 8270C, 8260B, 680, 8151 and 8081A, January 24, 2001**
  - 7 Surface Waters, 1 Sediment, and 2 Trip Blanks for Volatile Organic Compounds (VOCs).
  - 1 Surface Water and 1 Sediment for Semivolatile Organic Compounds (SVOCs), Pesticides, Polychlorinated Biphenyls (PCBs) and Herbicides
  - All Surface Water, Sediment and Trip Blank Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Methods 8270C, 8260B, 680, 8151 and 8081A, January 30, 2001**
  - 9 Surface Waters, 7 Sediments, 2 Equipment Blanks and 6 Trip Blanks for Volatile Organic Compounds (VOCs)
  - 8 Surface Waters, 7 Sediments and 2 Equipment Blanks for Semivolatile Organic Compounds (SVOCs), Pesticides, Polychlorinated Biphenyls (PCBs) and Herbicides
  - All Surface Water, Sediment and Trip Blank Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Methods 8270C, 8260B, 680, 8151 and 8081A, February 2, 2001**
  - 7 Surface Waters, 7 Sediments, 3 Equipment Blanks and 2 Trip Blanks for Volatile Organic Compounds (VOCs)
  - 7 Surface Waters, 7 Sediments and 3 Equipment Blanks for Semivolatile Organic Compounds (SVOCs), Pesticides, Polychlorinated Biphenyls (PCBs) and Herbicides
  - All Surface Water, Sediment and Trip Blank Results Usable for Project Purposes Except for Dinoseb which was Rejected in All Samples Due to Severe Quality Control Issues

- **Data Usability Review, Organic Analysis by Method 8290, February 12, 2001**
  - 4 Surface Water Samples for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Surface Water Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 13, 2001**
  - 4 Surface Water Samples and 2 Equipment Rinsate Blanks for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Surface Water and Blank Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 13, 2001**

- 4 Sediment Samples for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
- All Sediment Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 13, 2001**
  - 3 Sediment Samples for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Sediment Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 14, 2001**
  - 4 Surface Water Samples and 1 Equipment Blank for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Surface Water and Blank Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 15, 2001**
  - 3 Surface Water Samples and 2 Equipment Blanks for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Surface Water and Blank Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 16, 2001**
  - 4 Sediment Samples for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Sediment Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 16, 2001**
  - 3 Sediment Samples for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Sediment Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 19, 2001**
  - 1 Surface Water Sample for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Surface Water Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, February 19, 2001**
  - 1 Sediment Sample for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)
  - All Sediment Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Methods 8270C, 680, 8151 and 8081A, March 15, 2001**
  - 20 Fish Tissue Samples for Semivolatile Organic Compounds (SVOC), Pesticides, Polychlorinated Biphenyls (PCBs) and Herbicides
  - All Fish Tissue Results Usable for Project Purposes

- **Data Usability Review, Organic Analysis by Method 8290, March 20, 2001**
  - 20 Fish Tissue Samples for Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)

- All Fish Tissue Results Usable for Project Purposes

Validated analytical data were used to prepare the Ecological Risk Assessment summarized in Section 2.6.2.3.

2.5.1.4 USEPA Sediment Sampling

In October and November 2000, USEPA collected sediment samples in the Mississippi River in and adjacent to area of suspected groundwater discharge from Solutia's W.G. Krummrich plant (Figures 2-23 and 2-24). This work was performed in conjunction with Solutia's implementation of its Surface Water Sampling Plan using the same methods and sampling personnel, methods and equipment. Maximum detected concentrations in these samples are summarized below:

		Plume Discharge Area (Distance from Shore)			
	Upstream Reference Area	50 ft	150 ft	300 ft	Downstream Reference Area
VOCs (ppb)					
Acetone	ND	ND	ND	ND	ND
Benzene	ND	45	58	ND	ND
Chlorobenzene	ND	10,000	6,700	3,100	1.6
1,2-Dicloroethane	ND	110	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND
Toluene	ND	12,000	ND	ND	ND
Xylene	ND	120	ND	ND	ND
SVOCs (ppb)					
Aniline	ND	3,900	3,400	ND	ND
4-Chloroaniline	ND	3,300	6,400	ND	ND
1,2-Dichlorobenzene	ND	190	ND	ND	ND
1,3-Dichlorobenzene	ND	150	ND	ND	ND
1,4-Dichlorobenzene	ND	390	1,700	ND	ND
Phenol	ND	3,200	ND	ND	ND
2-Chlorophenol	ND	400	ND	ND	ND
2,4-Dichlorophenol	ND	610	ND	ND	ND

2,6-Dichlorophenol	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol	ND	ND	ND	ND	ND
3-Methylphenol	ND	93	ND	ND	ND
bis(2-ethylhexyl)Phthalate	ND	ND	ND	ND	ND
Organochlorine Pesticides (ppb)					
Aldrin	ND	ND	ND	ND	ND
alpha-BHC	ND	ND	ND	ND	ND
beta-BHC	ND	ND	ND	ND	ND
delta-BHC	ND	44	ND	ND	ND
gamma-BHC (Lindane)	ND	ND	ND	ND	ND
Chlordane (technical)	ND	ND	ND	ND	ND
Chlorobenzilate	ND	21	ND	ND	ND
4,4-DDD	ND	14	ND	ND	ND
4,4-DDE	ND	ND	ND	ND	ND
4,4-DDT	ND	ND	ND	ND	ND
Diallate	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endosulfan I	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND
Endosulfan sulfate	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Endrin aldehyde	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	ND	ND
Kepone	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND
Organophosphorus Pesticides (ppb)					
Dimethoate	ND	ND	ND	ND	ND
Disulfoton	ND	ND	ND	ND	ND
Famphur	ND	ND	ND	ND	ND
Methyl Parathion	ND	ND	ND	ND	ND
Phorate	ND	ND	ND	ND	ND
Tetraethyldithiopyrphosphate	ND	ND	ND	ND	ND
Thionazin	ND	ND	ND	ND	ND
o,o,o-Triethylphosphorothioate	ND	ND	ND	ND	ND
Herbicides (ppb)					

2,4-D	ND	790	ND	ND	ND
2,4,5-TP (Silvex)	ND	ND	ND	ND	ND
2, 4, 5-T	ND	ND	ND	ND	ND
PCBs (ppb)					
Aroclor 1016	ND	ND	120	ND	ND
Aroclor 1221	ND	ND	ND	ND	ND
Aroclor 1232	ND	ND	ND	ND	ND
Aroclor 1242	ND	ND	ND	ND	ND
Aroclor 1248	ND	84	20	ND	ND
Aroclor 1254	ND	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND	ND
TOC (ppm)	ND	11,000	7,400	ND	3,700

These data indicate that two VOCs (Chlorobenzene and Toluene) and three SVOCs (Aniline, 4-Chloroaniline and Phenol) occur at concentrations greater than one ppm in sediments at four sampling locations. Constituent concentrations at all sampling stations with detected concentrations are summarized below:

	Sampling Station							
Constituent Concentration, (ppb)	**PDA 2-60**	**MR-SD 2-150**	**MR-SD 4-90**	**PDA 5R-60**	**MR-SD 5-75**	**M R-SD 5-150**	**M R-SD 5-315**	**MR-SD 7-150**
Benzene	ND	55	4.2	ND	45	58	260	36
Chlorobenzene	10,000	390	100	450	1,800	6,700	3,100	1600
1,2-Dichloroethane	ND	ND	ND	110	ND	ND	ND	ND
Ethylbenzene	ND	ND	2	ND	ND	ND	ND	ND
Toluene	12,000	ND	ND	140	ND	ND	ND	ND
Xylenes	ND	ND	2.6	120	ND	ND	ND	ND
Aniline	210	ND	ND	3,900	2,400	3,400	ND	ND
4-Chloroaniline	720	99	ND	3,300	3,000	6,400	ND	58
1,4-Dichlorobenzene	390	ND	ND	ND	300	1,700	ND	ND
Phenol	ND	ND	ND	3,200	ND	ND	ND	ND
2-Chlorophenol	ND	ND	ND	400	ND	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND	610	ND	ND	ND	ND
3-Methylphenol	95	ND	ND	ND	ND	ND	ND	ND
PCBs	ND	ND	ND	ND	ND	120	38	20

Total Organic Carbon	11,000	ND	ND	390	200	7,400	ND	ND

USEPA's analytical data summaries are included in Table 2-24.

In order to interpret this data, Total VOC, Total SVOC and Total Organic Carbon concentrations were compared to sampling station distance from the northern, upstream boundary of Site R:

Sampling Station	Total VOCs (ppb)	Total SVOCs (ppb)	Total Organic Carbon (ppm)	Distance from Riverbank (feet)	Distance from North Boundary of Site R (feet)
MR-SD-2-150	445	99	ND	150	200
PDA -5R-60	820	11,410	390	60	1100
MR-SD-4-90	8.8	ND	ND	90	1300
MR-SD-5-75	1,845	5,700	200	75	1550
MR-SD-5-150	6,758	11,500	7,400	150	1550
MR-SD-5-315	3,360	ND	ND	315	1550
PDA -2-60	22,000	1,415	11,000	60	1800
MR-SD-7-150	1,636	58	ND	150	2300

Analytical data from these sampling stations appear to indicate that there are two plume discharge areas at Site R. One plume appears to be discharging from the northern half of Site R. A second plume appears to be discharging from the southern third of site R and the northern portion of Site Q. The north plume discharge area is composed primarily of SVOCs, specifically Aniline, 4-Chloroaniline and Phenol. The northern portion of the south plume-discharge area consists primarily of SVOCs, including Aniline, 4-Chloroaniline and Dichlorobenzene, although VOCs, primarily Chlorobenzene, make up a significant percentage of the constituents present. Chlorobenzene and Toluene are the dominant components of the southern portion of the south plume-discharge area.

Based on this data set, it appears that the northern plume discharge area extends more than150 ft but less than 300 ft from shore. Another observation that can be made from this data is that VOCs appear to be discharging at least 300 ft into the river at the southern plume discharge area. Total VOC concentrations are 1,845; 6758 and 3,360 ppb at distances of 75, 150 and 315 ft from shore, respectively, at sampling stations MR-SD-5-75, MR-SD-5-150 and MR-SD-5-315. Total SVOC concentrations at these sampling stations are, respectively, 5,700 ppb; 11,500 ppb and ND.

2.5.2 Sauget Area 2

In 1998, Ecology and Environment (E&E) prepared the report "Sauget Area 2 Data Tables/Maps for USEPA Region 5. This report summarized existing data for each site along with other information compiled by E&E during its file searches of various agencies and organizations. It contains data from investigations conducted by Clayton Environmental Consultants, Dynamac, E&E, IEPA, Geraghty and Miller, Reidel Industrial Waste Management, Russell and Axon and USEPA. Data for Sites O, P, Q, R and S are summarized in Sections 2.5.2.1, 2.5.2.2, 2.5.2.3, 2.5.2.4 and 2.5.2.5,. As part of its 1998 report, E&E prepared isoconcentration maps showing Total VOC concentration in shallow wells, Total VOC concentration in intermediate/deep wells, Total BNA concentration in shallow wells and Total BNA concentration in intermediate/deep wells. These maps are included in the FFS as Figures 2-25, 2-26, 2-27 and 2-28, respectively.

Based on the information contained in the E& E Report, a summary table showing relevant information for each sampling event was developed for Sites O, P, Q, R and S. These data are presented as Tables 2-5, 2-6, 2-7, 2-8 and 2-9, respectively. Additionally, maps indicating the locations of various sampling points for these previous investigations are presented as Figures 2-29, 2-30, 2-31, 2-32, 2-33 and 2-34 with Figure 2-29 providing an overall depiction of all sampling locations within Sauget Area 2. Figures 2-30 through 2-34 present locations of previous investigations at Sites O, P, Q, R and S, respectively. There was insufficient information in the E&E Report to accurately place all sampling points on the maps, therefore, not all of the investigative locations presented in Tables 2-5 through 2-7 appear on Figures 2-30 through 2-32.

2.5.2.1 Site O

The 1998 E&E report included the following information on Site O:

- Site Narrative

- Site Description
- Soil Samples
  - PCBs and Dioxin (IEPA, February 1983)
  - Benzene, Phenol and PCBs (Clayton Environmental, July 1984)
  - SVOCs and PCBs (Russell and Axon, July 1984)
  - VOCs, SVOCs, Pesticides and PCBs (Geraghty & Miller, August 1984)
  - VOCs, SVOCs, Metals, Pesticides, PCBs (E&E, February 1987)
- Groundwater Samples
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, September 1984)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1984)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, February 1985)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, May1985)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1985)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, February 1986)
  - VOCs, SVOCs, Metals (Geraghty & Miller, December 1986)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, March 1987)
  - VOCs, SVOCs, Metals (Geraghty & Miller, May 1987)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, July 1987)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1987)

Maximum, minimum, average and 95% UCL concentrations for Site O soil and groundwater data are given in Tables 2-10 and 2-11, respectively. These summary statistics are based on the information included in the 1998 Ecology and Environment Report "Sauget Area 2 Data Tables/Maps".

The following discussion concerning nature and extent of contamination at Site O was taken verbatim from the E&E Report:

> VOC concentrations in soil samples collected at Site O ranged from 0.001 to 889.9 mg/kg for 10 of 12 samples collected. BNAs were detected at concentrations ranging from 0.28 to 1,916 mg/kg in 9 of 12 samples collected. Pesticides were not detected in any of the 12 samples collected. PCB concentrations ranged from 11.4 to 1,871 mg/kg for 9 of the 12 samples collected. Metals, particularly Cu, Hg and Zn, were elevated in a few samples collected. The greatest contaminant concentrations in subsurface soils were detected at depths between 0 and 10 feet BGS.
>
> The extent of soil contamination at Site O is fairly well defined through the 12 samples collected at various depths, both within and adjacent to the lagoons. The lagoons are unlined, and were excavated into the Henry Formation sands. The lateral boundary of the lagoons is well defined and is readily evident in historical aerial photos.

2.5.2.2 Site P

The 1998 E&E report included the following information on Site P:

- Site Narrative
- Site Description
- Soil Samples
  - VOCs, SVOCs and Metals (E&E, February 1987)

Maximum, minimum, average and 95% UCL concentrations for Site P soil data are given in Table 2-12. These summary statistics are based on the information included in the 1998 Ecology and Environment Report "Sauget Area 2 Data Tables/Maps".

The following discussion concerning nature and extent of contamination at Site P was taken directly from the E&E Report:

> VOCs were detected at a concentration of 1.3 mg/kg in 1 of the 4 subsurface soil samples collected at Site P. BNAs were detected at 16.3 mg/kg in 1 of the 4 samples, and pesticides and PCBs were not detected in any of the four samples collected. Metals, particularly Pb and Hg were elevated in a few of the samples collected. The organic contaminants were all detected in the sample collected from boring P-1 at the south end of the site from a depth of 0 to 10 feet BGS.
>
> The extent of contamination is not very well defined for Site P given that only 4 subsurface soil samples were collected from three boring locations across the site. Although, the contamination detected does appear to be present at low levels.

2.5.2.3 Site Q

The 1998 E&E report included the following information on Site Q:

- Site Narrative
- Site Description
- Soil Samples
  - VOCs, SVOCs, PCBs and Dioxin (E&E, July 1983)
  - SVOCs, TCLP SVOCs, TCLP Metals, PCBs (E&E, May 1994)
  - VOCs, SVOCs, Metals, Pesticides, Herbicides and PCBs (IEPA, November 1994)

  - Metals and PCBs (E&E, 1997)
  - VOCs, SVOCs, TCLP Metals and PCBs (Reidel Industrial Waste Mgmt., Date Unknown)
- Surface Water Samples
  - Phenols, Metals and Inorganics (IEPA, October 1972)
  - Phenols, Metals and Inorganics (IEPA, April 1973)
- Leachate Samples
  - Phenols, Metals and Inorganics (IEPA, October 1972)
  - Phenol, PCBs, 2,3-D, Metals and Inorganics (IEPA, September/October 1981)
- Groundwater Samples
  - Phenols, Metals and Inorganics (IEPA, January 1973)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (E&E, March 1987)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (E&E, July 1987)

Maximum, minimum, average and 95% UCL concentrations for Site Q soil and groundwater data are given in Table 2-13 and 2-14, respectively. These summary statistics are based on the information included in the 1998 Ecology and Environment Report "Sauget Area 2 Data Tables/Maps".

The following discussion concerning the nature and extent of contamination at Site Q was taken directly from the E&E Report:

> <u>Southern Portion of Site Q (Samples X101 - X111 and Q203 - Q208):</u>
>
> VOC concentrations in soils ranged from 0.008 to 0.29 mg/kg for 5 of the 11 samples analyzed for these parameters. BNA concentrations ranged from 0.38 to 1.9 mg/kg for 5 of the 11 samples collected. Pesticides were not detected in any of the 11 samples analyzed for these parameters. PCB concentrations ranged from 0.06 to 223 mg/kg for 14 of 17 samples collected.
>
> The samples collected from the southern portion of Site Q are collected from depressional areas. These depressional areas have been identified by IEPA as apparent disposal areas and not all of the property south of the Alton & Southern Railroad has been sampled or characterized. The extent of surficial contamination in the southern portion of Site Q (south of the Alton & Southern Railroad) is fairly well defined laterally. However, there are no subsurface soils to help delineate the extent of vertical contamination.
>
> <u>Northern Portion of Site Q (all samples north of the Alton & Southern Railroad):</u>
>
> Waste samples (QD1 to QD3) collected in drums adjacent to the river at Site Q revealed BNA concentrations of 534 mg/kg in one sample, and PCB concentrations ranged from 180,000 to 260,000 mg/kg for the drum samples collected.

Surface water samples (P1 and P2) collected on Site Q did not contain appreciably high concentrations of metals. These samples were not analyzed for organic parameters. Pond sediments (Q201 and Q202) collected in the center of Site Q had PCB concentrations which ranged from 1.8 to 4.6 mg/kg for the two samples.

BNA concentrations in leachate samples (from samples L-1, L-2, L101, L102 and L103) were 5 µg/l for 2 of the 5 samples collected. The leachate samples were not analyzed for VOCs, and pesticides were not detected in any of the five samples. PCB concentrations ranged from 0.1 to 1.0 µg/l for 4 of the 5 samples collected. Metals, particularly As, Cr, Cu, Pb, and Zn, were elevated in a few of these samples.

VOC concentrations in subsurface soil samples (from borings B-1 to B-18 and Pits 1 & 2) ranged from 0.22 to 5,855 mg/kg for 28 of the 36 samples collected. BNA concentrations ranged from 3.8 to 15,190 mg/kg for 34 of the 36 samples collected. Pesticide concentrations were 0.1 and 3.3 mg/kg for 2 of the 35 samples collected. PCB concentrations ranged from 0.002 and 16,000 mg/kg for 32 of 36 samples collected. Dioxin (2,3,7,8-TCDD) concentrations in subsurface soil samples ranged from 0.0001 to 0.0033 mg/kg in 2 of 35 samples analyzed for this parameter.

The extent of contamination in the southern portion of Site Q (south of the Alton & Southern Railroad) is fairly well defined laterally in and around the depressional areas identified by IEPA. However, there are no subsurface soils to help delineate the extent of vertical contamination. The extent of contamination in the central portion of Site Q is poorly defined. Wastes have been identified through sampling of drum samples and leachate but surface and subsurface soil samples are lacking in this area. The extent of contamination in the northern portion of Site Q, adjacent to Site R is well defined through multiple soil borings and subsurface soil samples.

2.5.2.4 Site R

The 1998 E&E report included the following information on Site R:

- Site Narrative
- Site Description
- Soil Samples
  - VOCs, SVOCs, Pesticides and PCBs (IEPA, November 1994)
  - VOCs, SVOCs, Pesticides, PCBs and Dioxin (Dynamac, 1994)
  - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, April/May 1992)
- Surface Water Samples
  - Phenols, PCBs and Metals (IEPA, January 1973)

   - Dioxin (IEPA, 1981)
- Sediment Samples
   - VOCs, SVOCs, Pesticides and PCBs (IEPA, October 1981)
   - VOCs, SVOCs, Pesticides and PCBs (IEPA, November 1981)
   - Metals (E&E, November 1981)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, June 1992)
- Leachate Samples
   - Dioxin (USEPA, November 1981)
   - Metals, Dioxin (E&E, November 1981)
   - Dioxin (IEPA, March 1989)
- Groundwater Samples
   - Phenols, PCBs and Metals (IEPA, December 1972)
   - Phenols, PCBs and Metals (IEPA, February 1973)
   - Phenols, PCBs and Metals (IEPA, May 1974)
   - Phenols, PCBs and Metals (IEPA, October 1975)
   - Phenols, PCBs and Metals (IEPA, February 1976)
   - Phenols, PCBs and Metals (IEPA, October 1979)
   - SVOCs (IEPA, March 1981)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, June 1984)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, September 1984)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1984)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, June 1984)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, October 1985)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1985)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, February 1986)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, December 1986)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, March 1987)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, May 1987)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1987)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, May 1988)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, August 1988)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1988)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, March 1989)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, May 1989)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1989)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1990)
   - VOCs, SVOCs, Metals, Pesticides and PCBs (Geraghty & Miller, November 1991)
   - VOCs, SVOCs and Metals (Geraghty & Miller, June 1992)

Maximum, minimum, average and 95% UCL concentrations for Site R groundwater data are given in Tables 2-15 through 2-17. These summary statistics are based on the information included in the 2000 Solutia report "Descriptions of Current Conditions, W.G. Krummrich Facility, Sauget, Illinois". The DOCC was used as a source document instead of the 1998

Ecology and Environment report because Solutia collected most of the data included in the latter and this data was in an electronic database in the former.

The following discussion concerning nature and extent of contamination at Site R was taken directly from the E&E Report.

IEPA and USEPA File Information - Prior to 1992

Sample locations are situated adjacent to the river on the west side of Site R. Nine sediment samples (A, B, C, SO2, SO4, SO6, MO2, MO4 and MO6) were collected from six locations adjacent to the river west of Site R. VOCs were not detected in any of the three sediment samples analyzed for this parameter group. SVOC concentrations in sediments to the west of Site R ranged from 0.001 to 7.7 mg/kg for 9 of the 9 samples collected. Pesticides were not analyzed in these sediment samples. PCB concentrations in the sediments ranged from 0.00001 to 0.23 mg/kg for 6 of the 9 samples collected. Metals were not elevated in most of the samples collected. However, cyanide was detected at concentrations ranging from 6.8 to 90 mg/kg for all three samples analyzed for this parameter.

Nine leachate samples (X101D, X103D, X104D, SO1, SO3, SO5, MO1, MO3 and MO5 were collected from six locations adjacent to the river west of Site R. VOCs were not analyzed in any of the leachate samples. SVOC concentrations in the leachate to the west of Site R ranged from 0.6 to 12.3 µg/l for the three samples analyzed for this parameter group. Pesticide concentrations ranged from 0.5 to 3.0 µg/l for the three samples analyzed for this parameter group. PCBs were only detected in one leachate sample at a concentration of 0.08 µg/l. Samples X101D, X103D and X104D were analyzed for dioxins/furans only.

Total dioxin/furan concentrations ranged from 0.0001 to 0.0014 ppm. Metals were slightly elevated in some samples collected. Cyanide was detected in one leachate sample at a concentration of 71 µg/l.

Surface water samples (S101D, S103D and S104D) were collected from the Mississippi River and analyzed for dioxins/furans. The total dioxin/furan concentration ranged from 0.0001 to 0.0007 ppm in the three samples collected.

RI Report Data - Geraghty & Miller, 1994

Eight sediment samples (SS-1 through SS-8) were collected from stormwater drainage ditches surrounding the Site R landfill. VOC concentrations in sediment samples collected from the drainage ditches ranged from 0.002 to 0.035 mg/kg. Constituents detected in these sediment samples were similar to those detected in the landfill soil samples, although the detected concentrations were orders of magnitude lower. SVOC concentrations in sediments ranged from 0.045 to 3.99 mg/kg. Pesticides were only detected in one of the sediment samples at a concentration of 0.096 mg/kg. PCBs were detected at concentrations ranging from 0.08 to 1.5 mg/kg. Metals, particularly Al, Fe, Ca and Mg were elevated in some samples.

Soil samples were collected from 16 borings (SB-1 throuigh SB-16) within the landfill during the RI conducted by Geraghty & Miller. In addition, Dynamac completed an investigation in 1989 that included 8 borings (D-1 through D-8) around the perimeter of the landfill, 8 surface samples (C-1 through C-8) collected from the landfill cap and 10 surface samples collected from the perimeter (P-1 through P-10). VOC concentrations in subsurface soil samples collected from the RI borings ranged from 0.15 to 4,1000 mg/kg. VOC concentrations in subsurface soil samples collected by Dynamac from the RI borings ranged from 0.51 to 5,800 mg/kg. SVOC concentrations in subsurface soil samples collected from borings SB-1 through SB-16 ranged from 0.017 to 11,000 mg/kg. SVOC concentrations in subsurface soil samples collected by Dynamac ranged from 0.37 to 19,000 mg/kg. Pesticide concentrations in subsurface soil samples collected from the borings SB-1 to SB16 ranged from 0.011 to 99 mg/kg. Pesticides were not detected in any borings conducted by Dynamac. PCB concentrations in subsurface soil samples collected from borings SB-1 to SB-16 ranged from 0.075 to 4,800 mg/kg. PCBs were only detected in three of the borings conducted by Dynamac. Some metals, including As, Cr, PB, Ni and Hg, were slightly elevated in most samples.

Expanded Study area RI Report Data - Geraghty and Miller, 1994

Soil samples were collected from three borings (SB-17 through SB-19) drilled along the southern portion of the landfill. This area is actually part of Site Q but was investigated as part of the Site R by Geraghty & Miller. VOC concentrations in subsurface soil samples collected from these borings ranged from 0.002 to 1,640 mg/kg. SVOC concentrations in subsurface soil samples collected from borings SB-17 through SB-19 ranged from 0.041 to 185 mg/kg. Pesticide concentrations in subsurface soil samples collected from borings SB-17 through SB-19 ranged from 0.016 to 0.18 mg/kg. PCB concentrations in subsurface soil samples collected from borings SB-17 through SB-19 ranged from 0.36 to 6.6 mg/kg.

2.5.2.5 Site S

The 1998 E&E report included the following information:

- Site Narrative
- Site Description
- Soil Samples
  - VOCs, SVOCs, Metals, Pesticides and PCBs (IEPA, March 1995)
- Groundwater Samples
  - VOCs, SVOCs, Metals, Pesticides and PCBs (E&E, March 1987)

The following discussion concerning the nature and extent of contamination at Site S was taken directly from the E&E Report.

> VOC concentrations in soil samples collected from Site S ranged from 0.007 to 2,181 mg/kg in all six of the samples collected. BNAs were detected at concentrations ranging from 0.8 to 250 mg/kg for 5 of the 6 samples. Pesticides ranged from 0.005 to 0.2 mg/kg for 5 of the 6 samples. PCBs were detected in all six samples at concentrations ranging from 0.04 to 195 mg/kg. Metals, particularly Cr, Cu, Pb and Hg, were found at elevated concentrations in a few of the samples collected. At the time of sampling, surface leachate seeps were present at the southern portion of the site.
>
> The extent of contamination at Site S is poorly defined due to the limited number of sampling locations and associated analytical data. Samples were collected from locations X102 through X106 using a hand auger and the sample depths ranged from 0 to 5 feet BGS. High VOC, BNA and PCB concentrations present in samples X105 and X106 indicate that the extent of contamination at Site S has not been completely defined, either laterally or vertically.

2.6 Summary of Risks

2.6.1 Human Health Risk Assessment

Dynamac Corporation's Fort Lee, New Jersey office and Geraghty & Miller's Bethpage, New York office prepared a Human Health for Site R using data collected during an RI/FS required by an AOC with IEPA. Using data from prior site investigations, the risk assessors identified 29 chemicals of potential concern (COPCs):

VOCs	SVOCs	Pesticides/PCBs	Metals
• Benzene	• Aniline	• alpha-BHC	• Antimony
• Chlorobenzene	• 4-Chloroaniline	• PCBs	• Arsenic
• 1,2-Dichloroethane			• Beryllium
• Dichloroethylene	• 1,2-Dichlorobenzene		• Boron
• Methyl Chloride	• Nitrobenzene		• Nickel
• Methylene Chloride	• 2-Nitrochlorobenzene		• Thallium
• Tetrachloroethylene			• Cyanide
• Vinyl Chloride	• Phenol		

- 2-Chlorophenol
- 2,4-Dichlorophenol
- 2,4,6-Trichlorophenol
- Pentachlorophenol

- 2,4-Dimethylphenol

- Naphthalene

Potential exposure pathways are summarized below:

Potential Exposure Pathway	Chemical Source	Potential Exposure Scenario	Potential Receptors
Direct Contact	Clay Cap	Dermal Contact with and Incidental Ingestion of Soil	On-Site Maintenance Workers
Air	Clay Cap	Inhalation of VOCs and Dust	On-Site Maintenance Workers
Surface Water	Groundwater Discharge to Surface Water	Dermal Contact with and Ingestion of River Sediments	Trespassing Users of Mississippi River
		Fish Ingestion	Commercial and Recreational Users of Mississippi River

Potential risks due to direct contact and subsequent ingestion or dermal adsorption of constituents in, or adjacent to, landfilled materials were considered low because:

- The site is located in an exclusively industrial area and is fenced and patrolled by security personnel effectively eliminating the potential for residential exposure;

- Workers are the only likely receptors to present at the site and they would be present for limited periods of time to implement remedial actions or complete maintenance activities;

- A 2 to 6 ft thick, intact, highly-vegetated clay cover prevented direct contact with landfill contents; and

- Use of appropriate health and safety measures would limit worker exposures.

Potential risks due to direct contact with surface water were considered low because:

- Swimming does not occur locally due to the highly urbanized and industrialized nature of the Sauget area;
- Chemical concentrations are likely to be low to high dilution; and
- Exposure while fishing or boating would only be associated with incidental splash that is typically transient in nature and results in limited skin contact.

Potential risks due to inhalation of wind-blown dust from the landfill surface or entrained in the atmosphere by vehicular traffic associated with on-site remedial activities were considered low because:

- A thick clay cap covered the landfill;
- The cap was in good condition;
- Heavy vegetative cover on the cap would significantly limit dust emissions;
- With a depth to water averaging 12 ft, most excavated materials would be wet and not prone to dispersal by wind entrainment;
- Potentially-significant receptors were probably limited to on-site remediation workers with short term exposures; and
- Construction of a slurry wall and installation of a pump and treat system, the most likely remediation scenario, would not be likely to generate significant quantities of air-borne dust.

Potential risks due to inhalation of volatile organics from the landfill were considered low because:

- Remediation workers were the only potentially significant receptors;
- Escape of volatiles was limited by the vegetated, clay cap; and
- Most remediation activities would occur adjacent to but not in the landfill, thereby leaving the materials with the highest concentration of volatile chemicals undisturbed.

Potential risks due to ingestion of biota were considered significant because:

- Groundwater discharge from the landfill released an estimated 77 pounds per day of organic chemicals into the Mississippi River;
- Fish could accumulate at least one of the organic chemicals (chlorinated nitrobenzene) identified in Site R groundwater; and
- Commercial fishing was known to occur in the Mississippi River and recreational fishing was believed to occur.

Potential risks flora and fauna were considered significant because:

- Groundwater discharge from the landfill released an estimated 77 pounds per day of organic chemicals into the Mississippi River; and
- The Mississippi River was an active ecosystem.

Potential carcinogenic risks associated with realistic exposure scenarios for identified receptor groups indicated that the potential excess cancer risks for on-site workers and area residents consuming fish were less than 2.7×10^{-7} for all pathways combined. Even under worst-case exposure assumptions, the estimated excess lifetime carcinogenic risk for all pathways combined was 5.7×10^{-6}. Risk assessment results for the exposure pathways are summarized below:

Pathway	Worst-Case Exposures		Average-Case Exposures	
	On-Site Worker	Local Resident	On-Site Worker	Local Resident
Dermal Contact				
Surface Materials	4.5×10^{-7}	NA (1	6.2×10^{-8}	NA (1
Surface Water				
Adult	NA	1.3×10^{-6}	NA	NA
Child	NA	7.6×10^{-7}	NA	NA
Total	NA	2.1×10^{-6}	NA	NA
Incidental Ingestion				
Surface Materials	8.9×10^{-7}	NA	1.2×10^{-7}	NA
Surface Water				
Adult	NA	3.4×10^{-9}		

Child	NA	8.1×10^{-9}		
Total	NA	1.2×10^{-8}		
Inhalation				
Volatile Organics	9.5×10^{-7}	NA	1.1×10^{-8}	NA
Fish Ingestion				
Adult	NA	8.7×10^{-7}	NA	5.2×10^{-8}
Child	NA	4.9×10^{-7}	NA	2.9×10^{-8}
Total	NA	1.4×10^{-6}	NA	8.1×10^{-8}
Total	**2.3×10^{-6}**	**3.4×10^{-6}**	**1.9×10^{-7}**	**8.1×10^{-8}**
Overall Total (2	**5.7×10^{-6}**		**2.7×10^{-7}**	

Notes:

1) Not applicable, pathway not available to this receptor group.
2) Conservatively assumes that a receptor will be exposed via all pathways.

With respect to noncarcinogenic hazards, the analysis indicated that the hazard indices for all receptor groups and pathways combined were less than one for realistic exposure scenarios. Under worst-case assumptions, the combined hazard index was also less than one. Risk assessment results for the exposure pathways are summarized below:

Pathway	**Worst-Case Exposures**		**Average-Case Exposures**	
	On-Site Worker	**Local Resident**	**On-Site Worker**	**Local Resident**
Dermal Contact				
Surface Materials	6.2×10^{-4}	NA (1	3.1×10^{-4}	NA (1
Surface Water				
Adult	NA	6.1×10^{-2}	NA	NA
Child	NA	2.2×10^{-1}	NA	NA
Incidental Ingestion				
Surface Materials	2.2×10^{-3}	NA	1.1×10^{-3}	NA
Surface Water				
Adult	NA	1.7×10^{-4}		
Child	NA	2.3×10^{-3}		
Inhalation				
Volatile Organics	5.0×10^{-3}	NA	2.1×10^{-4}	NA
Fish Ingestion				

Adult	NA	5.4×10^{-2}	NA	3.0×10^{-3}
Child	NA	1.7×10^{-1}	NA	1.0×10^{-2}
Total Adult	**7.9×10^{-3}**	**1.1×10^{-1}**	**1.6×10^{-3}**	**3.0×10^{-3}**
Total Child	**NA**	**3.9×10^{-1}**	**NA**	**1.0×10^{-2}**
Overall Total (2	**5.1×10^{-1}**		**1.5×10^{-2}**	

Notes:

1) Not applicable, pathway not available to this receptor group.
2) Conservatively assumes that a receptor will be exposed via all pathways.

2.6.2 Ecological Risk Assessment

2.6.2.1 Dynamac (1994)

As part of the Human Health Risk Assessment prepared for the Site R RI/FS, Dynamac and Geraghty & Miller also prepared an Ecological Risk Assessment using data collected during the RI required by the IEPA AOC. Using data from prior site investigations, the risk assessors identified 29 chemicals of potential concern (COPCs):

VOCs

- Benzene
- Chlorobenzene
- 1,2-Dichloroethane
- Dichloroethylene
- Methyl Chloride
- Methylene Chloride
- Tetrachloroethylene
- Vinyl Chloride

SVOCs

- Aniline
- 4-Chloroaniline

- 1,2-Dichlorobenzene
- Nitrobenzene
- 2-Nitrochlorobenzene

- Phenol
- 2-Chlorophenol
- 2,4-Dichlorophenol
- 2,4,6-Trichlorophenol
- Pentachlorophenol

- 2,4-Dimethylphenol

- Naphthalene

Pesticides/PCBs

- alpha-BHC
- PCBs

Metals

- Antimony
- Arsenic
- Beryllium
- Boron
- Nickel
- Thallium
- Cyanide

Potential risks flora and fauna were considered significant because:

- Groundwater discharge from the landfill released an estimated 77 pounds per day of organic chemicals into the Mississippi River; and
- The Mississippi River was an active ecosystem.

Potential hazards to terrestrial biota were evaluated qualitatively. Due to the poor habitat available to support terrestrial wildlife, the presence of a clay cap on the landfill and the highly industrialized nature of the study area, potential terrestrial-wildlife exposures were likely to be limited. Consequently, risks to terrestrial organisms were likely to be limited.

Potential risks to aquatic organisms associated with groundwater releases to surface water were assessed quantitatively. This was done through acute toxicity bioassays for five species exposed to groundwater collected from three perimeter wells. Chronic toxicity bioassays were done for the most sensitive species tested. Bioassay results were used to derive a no observed effects concentration (NOEC) for site groundwater. This data, coupled with data on groundwater and surface-water flow rates, was used to derive an aquatic hazard index as a theoretical estimate of the potential hazards to aquatic organisms. Utilizing a safety factor of 10, the aquatic hazard index was found to equal 4.4 under average river flow conditions with no assumption for attenuation of toxicity with downstream distance or losses of toxic chemicals due to volatilization, adsorption, etc. For a 7Q10 river flow, the aquatic hazard index was 17.1.

Aquatic hazard index values greater than one suggested that, within the limitations of the methodology used to derive this number, potential impacts to aquatic life associated with groundwater discharge to the river could not be ruled out. Two conservative assumptions were used in calculating these results:

- Application of a ten-fold safety factor to provide a margin of safety for more sensitive species than those used in the groundwater bioassays; and
- Use of a simple dilution model to estimate constituent concentrations in surface water.

Although the data indicate that groundwater flowing into the river could have a potential impact on aquatic organisms, actual impacts were unknown. Testing of river water downstream of the

American Bottoms Regional Treatment Facility outfall indicated that aquatic toxicity could not be measured in using standard bioassay techniques in samples of river water collected immediately adjacent to the landfill. Furthermore, the data indicated that attenuation of toxicity is likely to be significant.

Acute toxicity studies of river water samples collected near the landfill suggested that attenuation of toxicity was likely to be rapid.

2.6.2.2 Environmental Science and Engineering (1995)

Environmental Science and Engineering's Amherst, New Hampshire office completed an ecological risk assessment for Site R in May 1995. The purpose of this risk assessment was to evaluate the potential for any adverse effects that constituents from the site might have on downstream ecological receptors within or depended upon the Mississippi River.

A reconnaissance of the site and surrounding area was performed on May 6, 1994. With the exception of a few trees, no natural (undisturbed) habitat appeared to remain on the site nor were any jurisdictional wetlands present. Birds were the only animals identified on site at the time of the visit. From the standpoint of terrestrial ecology, it was determined that all of the following factors precluded inclusion of a terrestrial component in the Ecological Risk Assessment:

- Presence of at least two feet of clean cap material;
- Lack of food and/or sparse vegetative cover;
- Low probability for recruitment of terrestrial species from surrounding areas; and
- Disturbed nature of the available habitat.

As a natural resource, the Mississippi River was considered very important.. However, the urban environment between Sauget and St. Louis and the physical (e.g. docks, barges and transfer stations) and the chemical (e.g. the ABRTF outfall) disturbances in the river could lead to defining this reach as a stressed ecosystem. Rip-rap along the western edge of the site provided shoreline stability but less than adequate riparian habitat for wetland-dependent birds or mammals. Organic chemicals in groundwater and the potential for migration to the Mississippi River presented an exposure pathway and potential risk to aquatic biota. This potential migration pathway and risk were the focus of the Ecological Risk Assessment. Only impacts to aquatic receptors that were directly or indirectly dependent on the river were considered in this assessment. Aquatic biota residing within or dependent on the Mississippi River downstream of Site R were considered the ecosystem at risk for this risk assessment.

With the exception of three constituents (Naphthalene, 4-nitrodiphenylamine and 2,4-D), SVOCs observed in soil and groundwater at Site R consisted primarily of four classes of compounds: Anilines, Chlorobenzenes, Phenols and Nitroaromatics. Anilines had the greatest mean concentration (82,000 to 100,000 ppb), followed by Nitroaromatics (31,000 to 75,000 ppb), Phenols (1,000 to 50,000 ppb) and Chlorobenzenes (100 to 3,000 ppb). Some of these constituents were considered to have the potential to cause adverse acute and/or chronic effects in fish and other aquatic biota. The central question of the risk assessment was "Do the concentrations of individual CO[P]Cs in the Mississippi River predicted by the groundwater flow model meet or exceed currently available criteria, standards, or toxicity endpoints for surface water and sediment?".

Groundwater modeling indicated that predicted concentrations of VOCs in surface water were well below 1 ppb. Since AWQC for the VOCs found at Site R were greater than 50 ppb, VOCs were eliminated as constituents of concern. For the remaining constituents found at the site, only compounds that could be adequately modeled were included in the risk assessment. In addition, only compounds with a detection frequency greater than 5 percent and a concentration greater than 1 ppm were included as COPCs. Constituents with concentrations less than one ppm were eliminated because they would have a concentration well below instrument detection limits when groundwater mixing with surface water. PAHs, phthalate esters, ethers and cresols were eliminated on that basis. Other constituents eliminated from consideration because they did not meet selection criteria were Benzidine; Benzyl Alcohol; 1,3-Dichlorobenzene; 3,3-Dichlorobenzidine; 2,4-Dinitrotoluene; Hexachlorocyclopentadiene; Isophorone; 2-Methylphenol; n-Nitrosodiphenylamine; and Triphenylphosphate.

Metals were eliminated from consideration because of the closeness of the measured groundwater concentrations to the range of instrument detection limits was less than a factor of three. In addition, most metal concentrations in groundwater were below levels expected for a highly industrialized area.

Although PCBs have a strong potential to bioaccumulate, they were eliminated from consideration because they were detected in less than 2 percent of the samples and, when detected, concentrations were less than 1 ppb. Of the pesticides, only 2,4-D met the criteria for inclusion in the risk assessment.

To estimate surface water concentration that fish or wildlife might be exposed to, the average surface-water exposure concentration of a constituent was determined by dividing the average groundwater loading rate to the river by the river's average daily flow. To estimate the constituent concentrations on suspended sediment, the average daily groundwater-load was evenly distributed in the average daily, suspended-sediment load of the river. Mean suspended sediment concentrations were determined by dividing the mean groundwater-loading rate by the mean daily discharge of suspended sediment to yield a bulk suspended sediment concentration.

Hazard Indices were calculated for each COPC in surface water by dividing the modeled exposure concentration in surface water by the respective AWQC or NOEL/LOEC. Hazard indices were calculated for each COPC in sediment by dividing the modeled exposure concentration in sediment by the respective Sediment Quality Value (SQV). SQVs were calculated by multiplying the Koc times the AWQC. The bulk (suspended) SQV was then derived by multiplying this value by the percentage of organic carbon assumed to be present in the sediment.

The results of these calculations are summarized below:

Constituent of Potential Concern	Hazard Indices	
	Surface Water	Sediments
Anilines		
Aniline	2.87E-02	1.07E-01
2-Chloroaniline	4.06E-03	1.51-E03
3-Choroaniline	1.02E-02	3.99E-03
4-Chloroaniline	2.62E-02	1.15E-02

2-Nitroaniline	4.78E-08	5.12E-08
4-Nitroaniline	1.30E-08	6.72E-09
Phenols		
Phenol	2.37E-05	2.43E-05
2-Chlorophenol	3.20E-07	6.70E-09
4-Chlorophenol	3.70E-08	1.38E-09
2,4-Dichlorophenol	4.64E-08	3.61E-09
2,4,6-Triclorophenol	5.22E-06	1.73-E06
Pentachlorophenol	8.69E-06	4.87E-09
4-Methylphenol	1.38E-05	4.93E-06
2,4-Dimethyphenol	1.78E-06	1.24E-07
4-Nitrophenol	1.62E-10	2.28E-10
Chlorobenzenes		
1,2-Dichlorobenzene	4.30E-04	7.50E-06
1,4-Diclorobenzene	1.96E-05	3.42E-07
1,2,4-Trichlorobenzene	1.43E-06	4.61E-09
Nitroaromatics		
Nitrobenzene	6.64E-06	5.45E-06
2-Nitrochlorobenzene	7.60E-05	1.29E-05
3-Nitrochlorobenzene	5.71E-04	6.57E-05
4-Nitroclorobenzene	5.14E-04	6.20E-05
Others		
Naphthalene	6.06E-06	6.36E-08
4-Nitrodiphenylamine	NC	NC
2,4-D	9.71E-04	4.46E-05

Hazard Indices were not be calculated for 4-Nitrodiphenylamine because AWQC or NOEL/LOEC values were not available for this constituent.

All of the conservatively derived Hazard Indices for surface water and sediment were below 1.0. Therefore, the COPCs associated with Site R posed no apparent threat to aquatic biota.

In the uncertainty analysis, ES&E stated that:

> "Realistically, concentrations of COPCs in the Mississippi River would be expected to be higher in surface water and sediment near the landfill as this assessment assumed "immediate" mixing across the river. However, a mixing zone study conducted for the American Bottoms Regional Wastewater Treatment Facility in Sauget indicated that mixing for a point source would be vertically complete approximately 1000 feet downstream of the discharge. As the discharge from the Site R landfill is a diffuse source, the mixing would be more efficient, and any putative impacts to biota would be very localized."

2.6.2.3 Menzie-Cura (2001)

Study Area - In June 2001, Menzie-Cura and Associates completed a Baseline Ecological Risk Assessment for the Mississippi River immediately downgradient of Site R. This baseline ecological risk assessment for the aquatic habitat adjacent to the W.G. Krummrich plant in Sauget, Illinois addressed surface water and sediment in the Mississippi River adjacent to Sauget Area 2 Site R (Figures 2-19, 2-20, 2-21 and 2-22). Study area boundaries, which extended approximately 2000 feet along the riverbank and 300 feet into the river channel, were defined during a reconnaissance survey completed in September 2000. The study area, defined using screening-level VOC analyses of sediment samples, is referred to as the Plume Discharge Area throughout the ecological risk assessment. In general, the study area is bounded by steep embankments lined with rip-rap. A few scattered structures, such as a wing dam and a sunken barge, offer some access points for aquatic birds and mammals and potential protection for fish. There were no bordering wetlands or appreciable bordering vegetation. No submerged or emergent vegetation was observed at the study area.

Surface water, sediment and fish tissues samples were collected in October and November 2000. River gage height varied from 2.03 feet to 0.08 feet, river depths ranged from 4 to 14.5 feet and flow varied from 78,800 to 97,500 cubic feet per second during the sampling effort. Both flow and gage height were below annual average for 2000:

	Mean Gage Height (Feet)	Mean Stream Flow (Feet)
Maximum	25.38	387,000
Average	6.04	135,716
Minimum	- 2.39	65,000

Reference areas were also selected during the ecological site reconnaissance and during the main sampling event. They were selected to represent industrial habitat comparable to the study area. One reference area with two sampling stations, one with coarse sediments and one with silty sediments, was located upstream of the study area just north of the old power plant and south of a railroad bridge. The shoreline is less obstructed than at the study area with the upland portion vegetated and grading into a sandy shoreline. A second reference area, also with one coarse sediment sampling station and one silty sediment sampling station, was located downstream near the Cahokia Chute and Arsenal Island. This reference area consists of a large sand bar, less-developed uplands, banks that provide direct access to the river and a number of partially-sunken snags. The upstream reference area is referred to as Upstream from the Discharge Area (UDA) and the downstream reference area is referred to as Downstream from the Discharge Area (DDA). All three habitats (PDA, UDA and DDA) are located in an industrialized area and there are a number of coal, grain and other barge terminals upstream of all the sampling areas.

Coarse sediment sampling stations contained over 90% fine to medium sand. Silty sediment sampling stations within the study area, UDA and DDA had similar clay components although the study area stations had a larger fine sand component. Coarse sediment TOC ranged from 324 to 700 mg/kg dry weight while silty sediment TOC ranged from 2,805 to 11,800 mg/kg dry weight. Dissolved oxygen, TDS and turbidity ranged from 7.62 to 10.57 mg/l, 287 to 367 mg/l and 34.4 to 55.6 NTU.

Analytical Data - Surface water, sediment and fish tissue analytical data are summarized in Tables 2-18, 2-19 and 2-20, respectively. Fish tissue data are summarized by species and by area in Table 2-21.

Three trophic levels of fish were sampled in the plume discharge area and in the upstream and downstream reference areas: 1) bottom feeder, 2) forager and 3) predator. Analytical results are summarized below. These results represent maximum detected concentrations of constituents present in whole body fish tissue samples collected in the plume discharge area downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area. Concentrations shown in bold print represent constituents detected only in the plume discharge area. Results from whole body fish tissue samples collected upstream and downstream of the plume discharge area are also included in this summary. PCBs were not detected in any of the fish tissue samples.

	Upstream	Plume Discharge Area	Downstream

SVOCS, µg/kg			
1,2-Dichlorobenzene	ND	**240** [1)]	ND
1,4-Dichlorobenzene	ND	**130** [1)]	ND
2,4-Dichlorophenol	ND	**190** [2)]	ND
2-Methylphenol	110	220	340
Herbicides, µg/kg			
2,4,5-T	7.1	13	ND
2,4,5-TP (Silvex)	7.5	8.7	6.9
MCPP	ND	**8600** [2)]	ND
Pesticides, µg/kg			
4,4-DDD	ND	**6.7** [3)]	ND
4,4-DDE	25	60	19
4,4-DDT	7.6	13	ND
alpha-BHC	ND	**2.6** [1)]	ND
alpha-Chlordane	5.6	14	7.7
gamma-Chlordane	5.8	8.1	3.5
Dieldrin	32	64	14
Endosulfan I	3	4.3	ND
Endrin	ND	**15** [2)]	ND
Endrin Aldehyde	7.4	10	4.9
Heptachlor epoxide	ND	**5.3** [2)]	ND
Dioxin, pg/g			
2,3,7,8- TCDD	3.3	2.4	0.96

Notes:

1) Detected in Forage Fish (Gizzard Shad)
2) Detected in Bottom Feeder Fish (Channel Catfish)
3) Detected in Predator Fish (Drum)

As can be seen from these data, eight constituents were only detected in the plume discharge area. Three SVOCs were only detected in fish tissue samples collected in the plume discharge area: 1,2-Dichlorobenzene; 1,4-Dichlorobenzene; and 2,4-Dichlorophenol. None of these concentrations exceed Toxicity Reference Values (TRVs). One herbicide, MCPP (Methyl Chlorophenoxy Propionic Acid) was only detected in the plume discharge area samples. Its maximum concentration in fish tissue was 8,600 ppb. MCPP is a broadleaf herbicide currently registered for use. LC50s for rainbow trout, sunfish and bluegill are 125 ppm, >100 ppm and 92 ppm, respectively. Reported biocentration factors (BCFs) range from 122 to 141 (low to moderate potential for bioaccumulation). Four pesticides were only detected in fish tissue samples from the plume discharge area: 4,4,4-DDD (6.7 ppb); alpha BHC (2.6 ppb); Endrin (15 ppb) and Heptachlor epoxide (5.3 ppb). Concentrations of 4,4,4-DDD; Endrin and Heptachlor epoxide were below their respective TRVs. There is no TRV for alpha BHC.

Toxicity Data - Surface water and sediment toxicity test results are summarized in Table 2-22. Benthic invertebrate community data are included in Table 2-23.

Sediment and surface water samples were collected at nine sampling stations in the Plume Discharge Area and acute and chronic toxicity testing were performed on these samples. Of these nine sampling stations, three showed benthic organism toxicity and three showed lotic organism toxicity:

	Sediment		Surface Water	
	Hyallela	Fathead Minnow	Fathead Minnow	Cerodaphnia
North Sampling Transect				
PDA - 8	No	No	No	Yes (1
PDA - 9	No	Yes (2 Yes (3	No	Yes (1
PDA - 10	No	No	No	No
Center Sampling Transect				
PDA - 5	Yes (4	Yes (4 Yes (5	No	Yes (1
PDA - 6	No	No	No	No
PDA - 7	No	No	No	No
South Sampling Transect				
PDA - 2	No	No	No	Yes (4 Yes (2
PDA - 3	No	Yes (2	No	Yes (1 Yes (4

		Yes [3]		Yes [1] Yes [2]
PDA - 4	No	No	No	Yes [4] Yes [1] Yes [2]

Notes:

1) Chronic Toxicity - Reproduction
2) Chronic Toxicity - Survival
3) Chronic Toxicity - Growth
4) Acute Toxicity - Survival
5) Acute Toxicity - Growth

Exposure Pathways - Potential complete exposure pathways in the study area include:

- Sediment to benthic invertebrates via direct contact and ingestion;
- Surface water to invertebrates and fish through direct contact and ingestion;
- Benthic biota to higher order predators (e.g. fish) through the food chain; and
- Fish to piscivorous fish, mammals and birds via ingestion.

Species selected as potential receptors represent the ecological community and its sensitivity to the contaminants of concern and were arrived at based, in part, on knowledge of the area and on discussions with USEPA and local professional fishermen. The ecological receptors selected for evaluation included: benthic invertebrates as a prey base for fish, local fin fish, great blue heron, osprey and river otter. In this assessment, drum, gizzard shad and channel catfish represent major groups of fish in the Mississippi River. They represent a bottom feeder, forage fish and a predator/omnivore bottom-feeding fish, respectively.

Assessment Endpoints - Two assessment endpoints were used in this ecological risk assessment: 1) sustainability (survival, growth and reproduction) of warm water fish species typical of those found in similar habitats (incorporates the assessment of aquatic invertebrates); and 2) survival, growth and reproduction of local populations of aquatic wildlife represented by osprey, great blue heron and river otter.

Constituents of Potential Concern - COPCs included the following constituents:

	Sediment	Water	Fish
VOCs			
Acetone	•		
Benzene	•	•	
2-Butanone	•		
Carbon Disulfide	•		
Chlorobenzene	•	•	
Chloroethane	•		
Chloroform	•		
1,2-Dichloroethane	•	•	
cis-1,2-Dichloroethene	•		
Ethylbenzene	•	•	
Methylene Chloride	•		
4-methyl-2-Pentanone	•	•	
Tetrachloroethylene	•		
Toluene	•	•	
Trans-1,2-Dichloroethylene	•		
Trichloroethylene	•	•	
Vinyl Chloride	•		
Xylenes	•	•	
SVOCs			
4-Bromophenylphenylether	•		
4-Chloroaniline	•	•	
2-Chlorophenol	•	•	
1,2-Dichlorobenzene	•	•	•
1,4-Dichlorobenzene	•		•
2,4-Dichlorophenol	•	•	•
2,4-Dimethlyphenol	•	•	
2,4-Dinitrotoluene	•		
2-Methylphenol			•
3-Methylphenol	•	•	
4-Methylphenol	•	•	
Naphthalene	•		
2-Nitroaniline	•		
Nitrobenzene		•	
Phenol	•	•	
2,4,6-Trichlorophenol	•	•	
Pesticides			
alpha-BHC			•
alpha-Chlordane			•

gamma-Chlordane			●
4,4'-DDD	●		●
4,4'-DDE			●
4,4'-DDT			●
Dieldrin			●
Endosulfan I			●
Endrin			●
Endrin aldehyde			●
Heptachlor epoxide			●
Herbicides			
2,4-D	●	●	
Dicamba		●	
Dichloroprop	●	●	
MCPP	●		●
Pentachlorophenol	●	●	
2,4,5-T			●
Silvex		●	●
Dioxin	●	●	●

Surface Water and Sediment Impact - The only COPCs in surface water that exceeded available guidelines (Tier II secondary chronic) were dioxin TEQs (Toxicity Equivalency Quotients) for mammals and birds at all study area stations and reference stations and m&p xylene at one PDA station. A conclusion of no significant risk from exposure to these COPCs could not be made based on the guideline comparison.

Sediment and surface water toxicity tests for analysis of survival and growth of fish result in toxicity at certain stations. The sediment toxicity tests indicated a significant reduction in survival at sand stations PDA-5 and PDA-9 and silt station PDA-3 (and PDA-3FD) in reference to controls; all three stations also resulted in a significant reduction in survival in comparison to all other study area, UDA and DDA stations except DDA-13 (sand). PDA-5 is 50 feet from shore on the middle transect, PDA-9 is 150 feet from shore on the northern transect and PDA-3 is 150 feet from shore on the southern transect. VOCs and herbicides (2,4-D, MCPP) are elevated at these stations. No significant reduction in growth was observed, excluding PDA-5, PDA-9 and PDA-3 (3FD). The surface water toxicity tests resulted in a significant reduction in survival at seven days in reference to laboratory controls for both downstream reference areas.

The sediment fish toxicity tests indicate potential reductions in survival for fish exposed to study area sediment with effects localized to samples approximately 150 feet from shore or less.

The components of the sediment triad include the sediment COPC screening, benthic community analysis and benthic invertebrate sediment toxicity testing. The COPC screening resulted in one guideline exceedance for naphthalene. The naphthalene concentration in sediment at PDA-3 exceeded the TEC (Threshold Effects Concentration). Risk due to guidelines exceedances is low, however, there are a number of compounds without applicable guidelines. The benthic community analysis was confounded by the high-energy conditions of the environment at study area (coarse grain and high current exposure). The study area benthic community included few taxa and low abundance. A similarly sparse community was found in the UDA samples. The DDA samples included a greater diversity and abundance. Because observations are confounded by the high-energy nature of the environment, this component of the triad is inconclusive. Because of the nature of the environment, the benthic community was predicted not to be a significant component of the fish prey base. Plankton, drift and periphytic communities are likely to be more important components of the fish prey base. Finally, the sediment toxicity tests with a benthic invertebrate resulted in a significantly lower survival in PDA-5 compared to the laboratory control and all other sand study area, DDA and UDA stations. No silt stations resulted in a significant reduction in survival. Growth was not significantly lower in all stations with the exception of PDA-5. PDA-5 is approximately 50 feet from shore and has elevated VOCs (clorobenzene, xylenes) and herbicides (2,4-D, MCPP and dichloroprop). The sediment triad component, toxicity testing, indicates impairment of the benthic community from exposure to sediments at PDA-5.

Surface water toxicity testing for the planktonic invertebrate, Ceriodaphnia dubia, resulted in significantly lower survival at 2 days and 7 days at PDA-2, PDA-2FD, PDA-3 and PDA-4 compared to control samples and all other samples. Both PDA -2 and PDA -2FD resulted in 0% survival at Day 2. Stations PDA-2 through PDA-4 comprise the southern, silty transect in the study area (50, 150 and 300 feet from shore, respectively). These stations have elevated SVOCs (4-chloroaniline), VOCs (chlorobenzene) and herbicides (2,4-D). Reproduction also was significantly reduced at PDA-5 (50 feet from shore on the middle transect) compared to the controls and all other stations, and at PDA-8 and PDA-9 in reference to two controls, but not the reference areas. The surface water planktonic invertebrate tests indicate a potential risk to planktonic invertebrates in terms of survival, and at one station, reproduction. However, it was assumed that water-column plankton were exposed to surface water at the sediment/surface water interface. The toxicity test exposures the plankton to this surface water for seven days. This is a conservative assumption because the surface water in the study area undergoes dynamic mixing and dilution continuously and water column plankton integrate exposures throughout the water column in the high energy environment.

Fish Impact - Several COPCs including dioxin, herbicides, pesticides and SVOCs were detected in fish from the study area at concentrations higher than those detected in fish from the UDA and/or the DDA reference areas, indicating that fish at the study area have a higher exposure. Of the COPCs detected in fish tissue, the study area fish tissue concentrations with available TRVs (Toxicity Reference Values) do not exceed the No Effect TRVs. However, TRVs are not available for some COPCs, particularly the phenoxy herbicides. For those compounds without TRVs, the comparison indicates that study area fish have a higher exposure than reference fish for a subset of detected COPCs. There is some uncertainty in this line of evidence because of the lack of TRVs for some compounds.

Fish species are at risk from direct exposure to study area sediments and due to threats to the prey base in sediment and surface water based on toxicity test results. However, based on the benthic survey information, the physical environment inherent to the Mississippi River under high-energy conditions reduces the importance of the benthic community as a prey base for fish communities. Planktonic invertebrates do serve as a prey base for fish species, however, the assessment assumes that they are exposed to dynamic water concentrations reflecting dilution and dispersion in the high-energy environment. Direct comparisons of COPC concentrations to guidelines indicate limited risk from exposure to a few compounds. Study area -specific COPCs, such as MCPP (Methyl Chlorophenoxy Propionic Acid), are present in study area sediment and fish tissue and are not detected in UDA or DDA samples indicating that the compounds are accumulating.

Wildlife Impact - Wildlife observations, specifically fish diversity, is similar at the study area, DDA and UDA. Habitat between these areas differs physically (study area steep and rocky shoreline) which may affect wildlife use, but this difference is not due to COPC concentrations. Comparison of COPC concentrations in surface water to wildlife drinking water benchmarks (NOAELs) indicated that no COPC for which there is a benchmark exceeded that benchmark.

Analysis of wildlife (birds and mammals) that utilize fish as a prey base and may be incidentally exposed to study area surface water and/or sediment and consume fish indicates that there is no significant risk of harm from exposure to study area media for any COPC with a TRV. However, no TRV was available for MCPP and other phenoxy herbicides and COPCs. MCPP is detected in study area sediment and fish tissue, but not in DDA or UDA sediment or fish tissue. Therefore, there is some uncertainty in this endpoint.

The analysis of potential risk to local populations for wildlife as represented by two bird and one mammal receptor species exposed to study area sediment, surface water and fish tissue indicates a low potential for risk. Observations do not indicate clear impacts to wildlife populations utilizing the study area.

In general, the impacts occur within 300 feet of shore. The toxicity tests indicate toxicity at four stations within 150 feet of shore. The surface water at one station, PDA-4, results in water column toxicity and is located approximately 300 feet from shore. This station is located downstream from the wing dam and is somewhat protected from river currents.

Summary - Menzie-Cura's Ecological Risk Assessment indicates that:

- Fish species are at risk from exposure to sediment based on the results of toxicity testing;
- Fish prey, such as planktonic invertebrates, are at risk from exposure to surface water based on toxicity tests. Planktonic invertebrates do serve as a prey base for fish species, however, the assessment assumes that they are exposed to surface water at the sediment-surface water interface. In reality, they are exposed to dynamic water concentrations reflecting dilution and dispersion in the high-energy riverine environment. Benthic organisms are also at risk from exposure to sediment based on laboratory toxicity tests. However, the inherent high-energy physical environment in the study area in the Mississippi River limits the number of benthic invertebrates. Therefore, benthic invertebrates are not abundant and are not considered an important prey component for fish at the study area.

- Fish are accumulating compounds, specifically MCPP [methyl-chlorophenoxy-propionic acid], detected in study area sediments but not detected in reference sediments.
- There is a low potential risk to wildlife foraging on the media (sediment, surface water and fish) in the study area.
- There are a number of compounds without applicable sediment, surface water or tissue guidelines. Comparisons of study area concentrations to reference concentrations indicate that a subset are found in concentrations in study area media that exceed the concentrations in reference media.
- In general, the impacts occur within 300 feet of the shoreline. All toxicity tests resulting in potential toxicity occurred within 150 feet of shore, with the exception of one station (PDA-4) at 300 feet. This station is located downstream of the wing dam in an area where surface waters are more protected from the strong currents.
- VOCs, SVOCs, and one herbicide are elevated at the surface water stations with toxicity, and VOCs, and herbicides are elevated at the sediment stations with toxicity.

2.7 Treatability Studies

The Advent Group of Brentwood, Tennessee conducted a groundwater treatability study for Solutia in 1992 (Groundwater Treatability Study, June 1993) using groundwater from Site R as influent. This pilot-scale test of a fluidized bed, attached biological growth, groundwater treatment system was undertaken as part of an RI/FS required by an AOC with IEPA. The purpose of this test was to evaluate treatment efficiencies and obtain treatment plant design parameters. Treatability test objectives were:

- Obtain a representative blend of groundwater for use in testing;
- Develop a treatment performance profile of the FBR (fluidized bed reactor) for the parameters of concern;
- Develop operational and design parameters for a full-scale FBR treatment system should one be constructed;
- Develop sludge handling process design parameters, if necessary;
- Determine off-gas rates and characteristics;
- Determine impacts of recalcitrant materials, if any; and
- Prepare process design and preliminary cost estimate for a full-scale FBR system.

To simulate both summer and winter operating conditions, the treatment system was operated from July 27 to November 16, 1992. From July 27 to October 15, 1992, unit temperature was 20 to 30°C to simulate summer conditions. After all necessary summer operating data were collected, a chiller was used to reduce feed temperature to between 9 and 14°C to simulate winter operations. A composite feed from existing Site R wells 28B, 56C and 57C was collected for treatment. Each well contributed approximately one third of the flow to the composite. Groundwater feed was stored in an equilization tank and pumped to the treatment system with a positive displacement pump.

A treatment system consisting of five unit operations was used to treat Site R groundwater (Figure 2-35). These sequential unit operations were:

- Biodegradation of organics with a fluidized bed reactor (FBR) using activated carbon as the growth medium and operating at a fluidization flow of 30 gpm and a forward flow of 0.4 to 1.5 gpm;
- Flocculation of solids;
- Clarification of solids;
- Filtration of solids using bag and cartridge filters in series; and
- Carbon polishing using two beds in series to remove any residual organics.

Treated effluent was discharged to the American Bottoms Regional Treatment Facility. Clarification, filtration and carbon adsorption were performed to insure that there would be no impact on the American Bottoms wastewater-treatment system.

Sludge from American Bottoms was the primary source of seed for the FBR although small quantities of microorganisms from other treatment facilities were also added during the acclimation period. To increase the rate of nitrification early in the study, the microbial population was supplemented with commercially obtained nitrifiers. After a three week long acclimation period, biological activity in the system stabilized and testing of varied organic loadings at warm and cold temperature conditions was started.

A wide-range of organics was effectively removed by the FBR. At a COD loading of 250 pounds per thousand cubic feet per day, the FBR system proved operable and capable of reliable VOC and SVOC removals approaching or exceeding 99 percent:

Constituent	Average Influent	Average Effluent	Percent Removal
VOCs, ppb			
Chlorobenzene	5,700	44	99.2
Toluene	1,350	< 5	99.8
Xylene	1,117	11	99.0
SVOCs, ppb			
2-Chloroaniline	37,667	11	> 99.9
4-Chloroaniline	16,650	< 30	> 99.9
1,2-Dichlorobenzene	2,867	90	96.9
2-Nitrochlorobenzene	129,667	330	99.7
4-Nitrochlorobenzene	41,167	57	98.7
Phenol	2,983	< 10	99.8
2-Chlorophenol	6,580	14	99.8
2,4-Dichlorophenol	5,583	13	99.8
Herbicides, ppb			
2,4-D	408	34	91.7
2,4,5-T	12.5	2	84.0
Soluble TOC, ppm	219	9	95.6
Soluble COD, ppm	754	23	96.9
Soluble BOD, ppm	201	2	99.0

Mass removal by air stripping was minimal with 0.00199% of the Chlorobenzene, 0.00351% of the 1,2-Dichlorobenezene and 0.00306% of the Toluene removed by this mechanism.

Treatment system influent and effluent VOC, SVOC, Herbicide and Metals analytical results are presented in Table 2-25.

Using information from the pilot-scale treatability test, Advent prepared a cost estimate for a full-scale system designed to treat a flow of 1500 gpm with a sustained COD load of 14,400 pounds per day. At this flow rate and loading, twelve, 22 ft-diameter FBRs were needed to treat extracted groundwater. Each reactor would use two pumps, of approximately 115 horsepower each, to fluidize the attached growth carbon bed at a recycle ratio of 33:1. Treated effluent would be discharged to the Mississippi River after flocculation and clarification. Sludge filter cake would be disposed at an off-site industrial waste landfill.

Installed treatment system costs, in rounded 1992 dollars, are summarized below:

Groundwater Collection System	$ 400,000
Influent Preparation	47,100
Fluid Bed Reactors	10,358,000
Solids Removal	253,500
Control Room/Laboratory	487,200
Subtotal	**$11,546,000**
Site Preparation (3%)	346,000
Piping (10%)	1,155,000
Electric (12%)	1,386,000
Installed Equipment Cost	**$14,087,000**
Engineering (20%)	2,817,000
Contingency (20%)	2,817,000
Total Installed Cost	**$19,721,000**

Annual treatment system operation and maintenance costs, in rounded 1992 dollars, are summarized below:

Labor	$ 467,200
Groundwater Recovery and Pretreatment	194,000
Fluid Bed Reactors	893,000
Sludge Treatment and Disposal	94,900
Laboratory Analyses	200,000
Maintenance (5% of Subtotal Installed Cost)	572,000

Total Annual O&M Costs $2,421,000

2.8 Local Limits Evaluation

To evaluate the feasibility of discharging groundwater recovered downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to the American Bottoms Regional Treatment facility, the Advent Group, Inc. conducted a desktop screening evaluation broadly based on the American Bottoms methodology for determining local limits. The purpose of the evaluation was to determine if any of the existing data indicated a potential to exceed any one of five screening criteria. If any criterion was exceeded, the removal efficiency required of American Bottoms to pass this criterion was presented.

The steps in the process can be summarized as follows

1) Prepare a data base using groundwater quality data collected from the Shallow, Middle and Deep Hydrogeologic Units in January and May 2000;

2) Establish groundwater flows resulting from installation of a physical barrier (535 gpm) and a hydraulic barrier (1,448 gpm);

3) Establish representative flow at American Bottoms (15 MGD);

4) Combine the estimated mass loads for the groundwater and American Bottoms flows and estimate the mean and maximum constituent concentrations for which data were available (Note - The effect of the PChem Plant was not included in this evaluation);

5) Constituents of concern were selected, on the basis of maximum concentrations in the data base, using the following screening method:

   - Constituents not sampled and analyzed at least once were eliminated due to insufficient data;
   - Constituents not detected were eliminated:
   - Constituents not detected at least twice were eliminated:
   - Constituents with maximum concentrations lower than the NPDES permit limits were eliminated;
   - Constituents with maximum concentrations lower than a water quality standard (with application of mixing zone dilution factors of 80, 230 and 2,820 to 1 for acute, chronic and human health water quality standards, respectively) were eliminated;

- Concentrations with maximum concentrations lower the minimum inhibition criteria for heterotrophic or nitrification activated sludge were eliminated;

5) Percent removal to prevent pass through or inhibition was calculated for each constituent that survived the screening process.

Constituents of concern, based on this local limits evaluation, are identified below for both low flow rate and high flow rate groundwater extraction systems.

	Low Flow Rate (724 gpm)	High Flow Rate (1,448 gpm)
Pass Through	4-Choloraniline 4-Nitroaniline	4-Chloroaniline 4-Nitroaniline
Inhibition	Aniline 2-Chlorophenol Pentachlorophenol Phenol	Aniline 2-Chlorophenol Pentachlorophenol Phenol

Low and high flow rates are based on Darcy flow through a 2000 ft. long seepage face downgradient of Sauget Area 2 Site R and two times the Darcy flow, which is the pumping rate required to capture groundwater upstream of this seepage face (Volume II - Design Basis and Design).

Removals required at the American Bottoms Treatment Facility to prevent pass through or inhibition, as identified in the local limits evaluation, are listed below along with the removals achieved in the pilot-scale groundwater treatability test conducted in 1993 using groundwater from Sauget Area 2 Site R as influent (Section 2.7).

	Local Limits Removal Required		Groundwater Treatability Study Removal Achieved (percent)
	Low Flow (percent)	High Flow (percent)	
Pass Through			
4-Chloroaniline	80	81	> 99.9
4-Nitroaniline	9	43	90.0
Inhibition			
Aniline	79	81	89.4
2-Chlorophenol	43	61	99.8
Pentachlorophenol	65	73	90.0
Phenol	74	78	99.8

Since American Bottoms uses the same treatment process (biodegradation) and carbon adsorption) as used in the Sauget Area 2 Site R pilot-scale groundwater treatability study, the POTW should be able to treat groundwater extracted downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area. American Bottoms submitted an NPDES permit renewal application in October 2001 that included a groundwater discharge from Sauget Area 2. A discharge permit application for this discharge will be submitted to American Bottoms in April 2002

3.0 IDENTIFICATION OF INTERIM REMEDIAL ACTION OBJECTIVES

The following Remedial Action Objectives (RAOs) were identified for the Interim Remedial Action:

- Prevent or abate actual or potential exposure to nearby human populations (including workers), animals or the food chain from hazardous substances, pollutants or contaminants;
- Prevent or abate actual or potential contamination of drinking water supplies and ecosystems;
- Achieve acceptable chemical-specific contaminant levels, or range of levels, for all applicable exposure routes; and
- Mitigate or abate other situations or factors that may pose threats to public health, welfare or the environment.
- Mitigate or abate the discharge of groundwater to the Mississippi River so that the impact is "insignificant" or "acceptable".

Focusing Interim Groundwater Remedy RAOs on the aquatic ecosystem is appropriate because sediment, surface water and fish tissue sampling, conducted in October and November 2000 as part of the WGK RCRA AOC, demonstrated that groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area adversely impacted the Mississippi River. Impacts due to the discharge of groundwater to surface water are confined to an area approximately 2000 feet long (coinciding with the north and south boundaries of Sauget Area 2 Site R) and 300 feet from shore immediately downgradient of Site R. Installation of a physical or hydraulic barrier downgradient of Sauget Area 2 Site R will reduce mass loading to the Mississippi River. Reduction of mass loading will abate aquatic organism exposure to impacted groundwater, contamination of ecosystems and sediment toxicity.

An Interim Groundwater Remedy can be implemented to abate aquatic impacts while the Sauget Area 2 Remedial Investigation/Feasibility Study is being performed to evaluate remedial alternatives that will abate impacts on groundwater. Once the Sauget Area 2 RI/FS is completed, a Final Groundwater Remedy can be selected.

Using "protect the river" as the primary remedial action objective for the Interim Groundwater Remedy would also reduce the impact of groundwater discharging to surface water to "insignificant" or "acceptable" levels, as required by the May 3, 2000 W.G. Krummrich RCRA AOC (USEPA Docket No. R8H-5-00-003), if groundwater from the Krummrich plant discharges to the Mississippi River at unacceptable levels.

For these reasons, the goal of the Interim Groundwater Remedy is to protect the Mississippi River by reducing mass loading to the river and, thereby, abating:

- Exposure of human populations, animals or the food chain to contaminants;
- Contamination of drinking water supplies and ecosystems;
- Chemical-specific contamination for all applicable exposure routes; and
- Threats to public health, welfare or the environment.

Mass loading, gradient control and sediment and surface water quality are appropriate performance measures for these Interim Groundwater Remedy remedial action objectives.

Sorption of constituents on suspended sediments in the surface water column after impacted groundwater discharges through river bottom sediments was not considered when evaluating performance measures for the Interim Groundwater Remedy. Constituents are migrating through the groundwater system in a dissolved and/or colloidal state. Prior to discharging to surface water, they migrate through sediments primarily composed of sand. On exiting the sand substrate, groundwater should mix rapidly with surface water. Given the high flow rate and turbulent mixing in the Mississippi River downgradient of Site R, it is difficult to envision a situation where constituents migrate through the groundwater system and river bottom sediments without binding to either matrix but do bind to suspended sediments in the surface water column when the discharging groundwater mixes with surface water. Even if this occurred, it is difficult to understand how a performance measure linked to constituent concentrations on suspended solids is a better performance measure for the Interim Groundwater Remedy than those discussed above. Control of, and performance measures for, this migration pathway can be considered during performance of the Sauget Area 2 RI/FS if it is determined that this is a viable migration pathway and that unacceptable impacts result from migration via this pathway.

3.1 Determination of Interim Remedial Action Scope

Implementation of institutional controls; groundwater quality, groundwater level and bioaccumulation monitoring; and installation and operation of an engineered barrier immediately downgradient of Sauget Area 2 Site R, as discussed in Section 5.2 and 5.3, will achieve these Remedial Action Objectives. Implementation of an Interim Remedial Action for impacted groundwater discharging to surface water will, in the short term, prevent or abate actual or potential human and ecosystem exposure to hazardous substances, pollutants and contaminants and actual or potential contamination of drinking water supplies. In the long term, operation of an engineered barrier may achieve acceptable chemical-specific contaminant levels downgradient of the barrier. Other situations or factors that may pose threats to public health, welfare or the environment will be mitigated or abated both short term and long term by implementation of an Interim Remedial Action. Aquifer restoration, which will be evaluated in the Sauget Area 2 RI/FS, is not within the scope of the interim remedial action.

3.2 Determination of Interim Remedial Action Schedule

Barring unforeseen difficulties with regulatory approvals, site access or issuance of a permit to allow discharge of pumped groundwater to the PChem Plant and the ABRTF, design and construction of an engineered barrier and installation of power, pumps, piping, controls, etc. should take approximately 12 months.

3.3 Identification of and Compliance with ARARs

In keeping with an interim remedial action for impacted groundwater discharging to surface water and streamlining principles in FS guidance, only chemical-specific, location-specific or action-specific ARARs that are considered applicable or relevant and appropriate are identified in this section. Compliance of identified remedial alternatives with ARARs is discussed in Detailed Analysis of Alternatives Sections 5.1.2, 5.2.2 and 5.3.2.

3.3.1 Chemical-Specific ARARs

Chemical-specific ARARs define acceptable concentrations and are used to establish preliminary remediation goals. Brief descriptions of the relevance and applicability of chemical-specific ARARs for groundwater are summarized in the following table:

ARAR	Description	Applicability
40 CFR 141.61	MCLs for organic chemicals for drinking water	Applicable
40 CFR 141.62	MCLs for inorganic chemicals for drinking water	Applicable
40 CFR 264.92	Establishes groundwater protection standards for hazardous waste treatment and disposal facilities	Relevant and Appropriate
40 CFR 264.94	Establishes maximum concentration limits. Provides for establishment of alternate limits for groundwater protection	Relevant and Appropriate
40 CFR 264.95	Establishes point of compliance for which groundwater quality standards apply	Relevant and Appropriate
35 IAC 620	Defines classes of groundwater within the State of Illinois	Applicable
35 IAC 620.410	Establishes numeric groundwater quality standards for Class I Potable Groundwater	Applicable
35 IAC 620.250	Provides for establishment of a groundwater management zone to mitigate impairment	Applicable
35 IAC 620 Subpart D	Establishes groundwater quality standards for classes of groundwater. Provides for establishing alternative groundwater quality standards for any chemical constituent in a groundwater management zone	Applicable

According to the "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration" (Interim Final, OSWER Directive 9234.2-25, September 1993, Page 5), the Agency can waive chemical-specific ARARs for an interim remedy under certain conditions:

> "It is important to note that for interim actions, ARARs must be attained only if they are within the scope of that action. For example, where an interim action will manage or contain migration of an aqueous contaminant plume, MCLs and

MCLGs would not be ARARs, since the objective of the action is containment, not cleanup (although requirements such as those related to discharge of the treated water would still be ARARs, since they address the disposition of treated waste).

Furthermore, a requirement that is an ARAR for an interim action may be waived under certain circumstances. An "interim action" ARAR waiver may be invoked where an interim action that does not attain an ARAR is part of, or will be followed by, a final action that does (NCP Section 300.430 (f)(1)(ii)(C). For example, where an interim action seeks to reduce contamination levels in a groundwater hot spot, MCLs/MCLGs may be ARARs since the action is cleaning up a portion of the contaminated groundwater. If, however, this interim action is expected to be followed by a final, ARAR-compliant action that addresses the entire contaminated groundwater zone, an interim action waiver may be invoked."

Since the objective of the interim remedial action for groundwater discharging to surface water downgradient of Sauget Area 2 Site R is to "manage or contain migration of an aqueous contaminant plume" and it "is part of, or will be followed by, a final action that does [attain ARARs], a waiver of chemical-specific ARARs by the Agency appears to be appropriate. A Remedial Investigation/Feasibility Study (RI/FS) for Sauget Area 2 Sites is currently underway. Final remedial actions for groundwater will be evaluated as part of this RI/FS.

3.3.2 Location-Specific ARARs

Location specific ARARs set restrictions on activities within certain locations such as floodplains or wetlands. A brief description of the relevance and applicability of location-specific ARARs is summarized in the following table:

ARAR	Description	Applicability
40 CFR Part 6 and Appendix A	Requires Federal agencies to evaluate the potential effects of actions to avoid adversely impacting floodplains	Applicable

3.3.3 Action-Specific ARARs

Action-specific ARARs set controls for particular treatment and disposal activities related to the management of hazardous waste. Brief descriptions of the relevance and applicability of action-specific ARARs are summarized in the following table:

ARAR	Description	Applicability
40 CFR 125	Establishes technology-based limits for direct discharge of treatment system effluent	Applicable
40 CFR 403.5	Specifically prohibits the direct discharge of pollutants to a publicly-owned treatment works without treatment, that interfere with operations, or that contaminate sludge	Applicable
29 CFR 1910.120	Standards for conducting work at hazardous waste sites	Applicable
29 CFR 1926	OSHA safety and health standards	Applicable
35 IAC 306.302	Standards for expansion of existing or establishment of new combined sewer service areas	Relevant and Appropriate
35 IAC 307.1101	Sewer discharge criteria that prohibit entry of certain types of pollutants into a POTW	Applicable

4.0 IDENTIFICATION OF INTERIM REMEDIAL ALTERNATIVES

The purpose for this section is to identify and screen technologies that are potentially suitable for ensuring adequate protection of human health and the environment considering specific groundwater conditions at the site. The following subsections identify remedial action objectives, discuss general response actions and identify and screen remedial technologies and processes.

4.1 General Response Actions

General response actions describe those actions that will satisfy the remedial action objectives. General response actions may include treatment, containment, extraction, institutional controls, monitoring or a combination thereof. General response actions for impacted groundwater discharge to surface water include the following:

- Institutional Controls
  - Access Restrictions
  - Warning Signs
  - Community Relations
- Engineered Barriers
  - Physical Barriers
    - Slurry Walls
    - Jet Grout Walls
  - Hydraulic Barriers
- Monitoring
  - Groundwater Water Quality Monitoring
  - Groundwater Level Monitoring
  - Bioaccumulation Monitoring

The following sections describe technology types and process options for groundwater that could satisfy the remedial action objectives for the discharge of groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

4.1.1 Institutional Controls

Institutional controls can include access restrictions to the area of interest, as well as regulations restricting specific activity within the area of interest. Institutional controls already in place at Site R include fencing to control access and excavation restrictions to prevent trenching without appropriate protection of construction workers. Additional institutional controls, such as posting, could be implemented to prevent recreational fishing in the area where impacted groundwater discharges to surface water.

4.1.2 Engineered Barriers

The primary purpose for an engineered barrier is to prevent groundwater causing adverse ecologic impacts from discharging to the Mississippi River. Engineered barriers could include physical barriers, such as slurry or jet grout walls, or hydraulic barriers, such as extraction wells, or a combination of physical and hydraulic barriers. Engineered barriers can be designed to prevent off-site discharge of groundwater causing adverse ecological impacts in surface water and to reduce the mass of contaminants discharging to surface water.

4.1.3 Monitoring

4.1.3.1 Groundwater Quality Monitoring

Groundwater quality monitoring involves periodic monitoring of selected wells for constituents of concern to demonstrate reduction in mass loading to the Mississippi River resulting from the discharge of groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

4.1.3.2 Groundwater Level Monitoring

Groundwater level monitoring involves periodic measurement of water level elevations in selected piezometers to demonstrate the hydraulic effectiveness of the engineered barrier in abating the discharge of groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

4.1.3.3 Surface Water and Sediment Monitoring

Sediment and surface water samples will be collected in the plume discharge area downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to determine the effect of any contaminants migrating through, past or beneath the barrier wall and discharging to the Mississippi River. Impact will be determined by comparing constituent concentrations to site-specific, toxicity-based, protective concentrations derived from existing sediment and surface water chemistry and toxicity data. In this context, it must be recognized that it may take some time for observable decreases in sediment concentration to occur after the installation of the barrier wall.

4.2 Identification and Screening of Alternatives

This section describes technologies and processes that could satisfy the remedial action objectives for groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area. Technology types refer to the general response actions that were described in Section 4.1. General response actions for groundwater include institutional controls, monitoring and engineered barriers. The following subsections describe technology types and process options for groundwater.

4.2.1 Institutional Controls

Institutional controls are measures designed to mitigate potential exposure to impacted groundwater discharging to surface water. As previously discussed, some institutional controls are already in place at Site R. The existing institutional controls and additional institutional controls to be considered are described in the following sections.

4.2.1.1 Access Restrictions

Access restrictions include physical restrictions such as the use of fencing and locked gates. Access to Site R is already controlled by the presence of fencing and locked gates. Restrictions are already in place for Site R that define requirements for training, protection and monitoring of construction and outdoor industrial workers. Industrial and construction workers doing any type of invasive work are trained for high hazard material exposure, hazardous waste site operations, advised of the complete range of chemical and physical hazards to which they may be exposed, and provided with personal protective equipment to mitigate all identified inhalation, ingestion, and dermal contact risks.

4.2.1.2 Warning Signs

Warning signs discourage access and unauthorized excavation activities. They can be posted on security fencing and in other areas as needed. Implementation will be in conjunction with the response action for Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W. G. Krummrich plant and other industrial facilities in the Sauget area.

4.2.1.3 Community Relations

Community relations may include an information campaign designed to ensure public awareness about the risks, if any, associated with potential ingestion of fish caught in or near where impacted groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W. G. Krummrich plant and other industrial facilities in the Sauget area discharges to the Mississippi River.

4.2.2 Engineered Barriers

Engineered barriers are designed to mitigate discharge of groundwater with contaminant concentrations in excess of standard. Engineered barriers could potentially be placed adjacent to source areas, or they could be placed near the downgradient boundary of Sauget Area 2 Site R. Since an interim remedial action is needed to abate the impact resulting from the discharge of impacted groundwater from these source areas, it is appropriate to install an engineered barrier downgradient of these sites immediately adjacent to the Mississippi River.

Engineered barriers selected for screening include physical barriers (slurry walls and jet-grouted walls) and a hydraulic barrier.

4.2.2.1 Slurry Walls

Slurry walls are subsurface barriers that mitigate the horizontal flow of contaminants and groundwater. Permanent slurry walls are generally constructed with cementitious or pozzolanic agents that are mixed with in situ or imported earthen materials. Slurry walls generally can be hanging walls, which extend to a prescribed depth below surface, or fully-penetrating walls, which terminate at or are keyed into the underlying bedrock.

Considering that affected groundwater extends to depths in excess of 100 feet, a hanging slurry wall may not be a completely effective alternative for accomplishing the remedial objective of controlling or mitigating the discharge of impacted groundwater to the Mississippi River. Consequently, a hanging slurry wall was not considered further in this analysis.

Two site-specific issues appear to make installation of a fully penetrating slurry wall impracticable: 1) keying the slurry wall into bedrock and 2) slurry trench spoil disposal. It is not practical to key a slurry wall into bedrock at the 100 to 140 foot depths required at this site. In fact, USEPA publication 542-R-98-005, *Evaluation of Subsurface Engineered Barriers at Waste Sites*, August 1998, states, "The greatest difficulty in achieving adequate key depth was encountered at sites at which fractured bedrock occurred at depths of more than 70 feet below ground surface."

Terminating the slurry wall at bedrock may be practicable because the amount of groundwater flow through weathered or fractured bedrock is likely to be a very small fraction of the flow in the alluvial aquifer. However, the second limiting issue comes into play if it is feasible to terminate the wall at bedrock. Slurry trenches are typically 2 to 3 feet wide. Consequently, construction of a 3,500 ft. long slurry wall with an average depth of 120 ft. will result in 30,000 to 50,000 cubic yards of spoil depending on trench width. Spoil disposal becomes a serious practicability issue if it can not be used as slurry trench backfill after mixing with low-permeability materials or if it can not be disposed on site. Most of the spoil will be sand-sized material, which is a suitable material for slurry trench backfill. Without compatibility testing it is not possible to determine whether or not the constituents present in the spoil will adversely affected its performance as backfill.

On-site disposal does not appear feasible unless the spoil can be stockpiled on Sauget Area 2 Site R until a final remedy decision is made on Sauget Area 2 source areas. A temporary stockpile on the wet side of the USACE floodwall may not be an appropriate management alternative for this material because of the potential adverse consequences that could result during flood conditions. Off-site disposal of 30,000 cubic yards (45,000 tons) of spoil will cost $90,000,000, assuming $2,000 per ton for transportation and disposal, if Universal Treatment Standards need to be met prior to disposal in a hazardous waste landfill.

For these reasons, a fully penetration slurry wall will not be considered further, based on apparent impracticability.

4.2.2.2 Jet-Grouted Walls

Jet-grouted walls are subsurface barriers that mitigate the horizontal flow of contaminants and groundwater. Permanent jet-grouted walls are generally constructed with cementitious or pozzolanic agents that are mixed with in situ soils. Mixing is accomplished by inserting a rotating grouting rod into the subsurface. Low-permeability grout is pumped through the rod under very high pressure and mixes with the in-situ soil. This creates a column of low-permeability soil from bedrock to above the water table. A wall is constructed by installing contiguous soil/grout columns along the barrier wall alignment.

Jet-grout walls generally can be hanging walls, which extend to a prescribed depth below surface, or fully penetrating walls, which terminate at bedrock. Considering that affected groundwater extends to depths in excess of 100 feet, a hanging jet-grout wall may not be a completely effective alternative for accomplishing the remedial objective of controlling or mitigating the discharge of impacted groundwater to the Mississippi River. Consequently, a hanging jet grout wall will not be considered further in this analysis. Terminating the jet-grout wall at bedrock may be practicable and is likely to achieve remedial objectives because the amount of groundwater flow through weathered or fractured bedrock is likely to be a very small fraction of the flow in the alluvial aquifer. Little or no spoil is generated during installation of a jet grout wall. As a result, a jet grout barrier wall is considered a practicable physical barrier wall technology.

4.2.2.3 Hydraulic Barriers

Hydraulic barriers consist of one or more groundwater recovery extraction wells that collect groundwater and contaminants and pump them to the surface. Hydraulic barriers provide containment both by intercepting contaminated groundwater and by providing hydraulic control. Installing a line of extraction wells along a riverbank will create a hydraulic barrier that captures impacted groundwater prior to its discharge to surface water. Design and operation of a hydraulic barrier need to be optimized to maximize the capture of impacted groundwater and minimize the capture of recharge from the Mississippi River. If the area of influence of the hydraulic barrier were to extend into the Mississippi River, pumping and treatment costs would increase significantly without a corresponding increase in environmental protection.

4.2.3 Monitoring

4.2.3.1 Groundwater Quality Monitoring

Groundwater quality monitoring typically involves the design and installation of a groundwater monitoring system to monitor the existing leaks of contaminants from source areas and/or to demonstrate that a groundwater plume is stable or shrinking, which is a primary line of evidence regarding the adequacy of the selected remedial alternative. Monitoring leakage from source areas or demonstrating plume stability/shrinkage is not an appropriate design concept when impacted groundwater is discharging to surface water. In this situation, groundwater monitoring needs to be performed downgradient of any implemented control measures in order to determine the effectiveness of these measures. An appropriate groundwater-monitoring program will identify specific monitoring wells, constituents of concern, and frequency of monitoring. The duration of this procedure will continue until compliance with remedial action objectives is achieved.

Groundwater quality samples will be collected downgradient of the engineered barrier to determine mass loading to the Mississippi River resulting from any contaminants migrating through, past or beneath the barrier. Groundwater quality samples will be collected from four monitoring well clusters and analyzed for VOCs, SVOCs, Herbicides, Pesticides and Metals. TOC and TDS will also be determined for each sample.

4.2.3.2 Groundwater Level Monitoring

Groundwater level monitoring will be done to ensure acceptable performance of an engineered barrier installed to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

4.2.3.3 Surface Water and Sediment Monitoring

Sediment and surface water samples will be collected in the plume discharge area downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to determine the effect of any contaminants migrating through, past or beneath the barrier wall and discharging to the Mississippi River. Impact will be determined by comparing constituent concentrations to site-specific, toxicity-based, protective concentrations derived from existing sediment and surface water chemistry and toxicity data. In this context, it must be recognized that it may take some time for observable decreases in sediment concentration to occur after the installation of the barrier wall.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents evaluation of alternatives in the context of specific evaluation criteria developed to address CERCLA requirements and technical and policy considerations proven to be important for selecting remedial alternatives. An ecological risk assessment performed in June 2001 indicates there is an adverse impact on the Mississippi River resulting from the discharge of groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area. Based on this risk assessment, it is appropriate to take an Interim Remedial Action to protect the Mississippi River before the Sauget Area 2 RI/FS is completed, the Sauget Area 1 ROD is issued and the RCRA Corrective Measures Study is performed for the Krummrich plant. An engineered barrier located at the downgradient edge of the impacted groundwater plume is the only effective interim remedy that will achieve the objective of protecting the Mississippi River. For that reason, only three alternatives are compared in this Focused Feasibility Study:

- **Groundwater Alternative A - No Action**
- **Groundwater Alternative B - Physical Barrier**
  - Institutional Controls
  - Physical Barrier
  - Groundwater Treatment
  - Monitoring
    - Groundwater Quality Monitoring
    - Groundwater Level Monitoring
    - Bioaccumulation Monitoring
- **Groundwater Alternative C - Hydraulic Barrier**
  - Institutional Controls
  - Hydraulic Barrier
  - Groundwater Treatment
  - Monitoring
    - Groundwater Quality Monitoring
    - Groundwater Level Monitoring
    - Bioaccumulation Monitoring

The No Action, Physical Barrier and Hydraulic Barrier alternatives are discussed in Sections 5.1, 5.2 and 5.3, respectively. Feasibility Study guidance requires that these alternatives be evaluated according to the following criteria:

- Overall protection of human health and the environment;

- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility or volume;
- Short-term effectiveness;
- Implementability; and
- Cost.

Additional criteria include State acceptance and community acceptance. EPA will consider and address both State and community acceptance of an alternative when making a recommendation and in the final selection of a remedy. Consequently, these criteria are not addressed in this report.

5.1 Groundwater Alternative A - No Action

This alternative includes no actions to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area.

5.1.1 Overall Protection of Human Health and the Environment

The June 2001 Ecological Risk Assessment (Menzie-Cura) demonstrated that groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area adversely impacted sediment and surface water in the Mississippi River. In addition, site-specific compounds were present in fish tissue collected in this area at higher concentrations than were detected in fish tissue collected upstream and downstream of the plume discharge area. Implementation of a No Action alternative will not protect the Mississippi River from adverse ecological impact due to the discharge of impacted groundwater to surface water.

5.1.2 Compliance with ARARs

If the Agency waives compliance with chemical-specific ARARs as allowed by guidance (Section 3.3.1), Groundwater Alternative A - No Action would not need to achieve compliance with these ARARs. A No Action alternative will not adversely impact floodplains or wetlands, so it is compliant with location-specific ARARs. Action-specific ARARs do not apply because there are not actions.

5.1.3 Long-Term Effectiveness and Permanence

Since no action is taken to abate the impact of groundwater discharge to the Mississippi River downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area, a No Action alternative is unlikely to be effective or permanent in the long-term.

5.1.4 Reduction of Toxicity, Mobility or Volume

In the long term, natural processes in groundwater, sediments and surface water will reduce the toxicity, mobility and volume of contaminants discharging to the Mississippi River. Natural processes such as biodegradation, adsorption, dilution, volatilization and chemical reactions with subsurface materials will reduce contaminant concentrations in the groundwater system. Similar processes occur in sediments and surface water. However, this alternative does not provide for treatment beyond that afforded by natural processes.

5.1.5 Short-Term Effectiveness

The primary potential risk to human health will not be addressed if a No Action alternative is implemented. In addition, a No Action alternative will not reduce adverse impacts on the Mississippi River in the short term.

5.1.6 Implementability

This alternative is readily implementable.

5.1.7 Cost

No costs are associated with this alternative.

5.2 Groundwater Alternative B - Physical Barrier

Alternative B includes the following elements:

- Institutional Controls
- Physical Barrier
- Groundwater Treatment
- Monitoring
  - Groundwater Quality Monitoring
  - Groundwater Level Monitoring
  - Surface Water and Sediment Monitoring

Institutional Controls - This alternative includes institutional controls in combination with a well-designed performance-monitoring program. Institutional controls will be utilized to limit fishing in the plume discharge area while performance monitoring will be used to evaluate the effectiveness of the physical barrier in mitigating or abating the discharge of groundwater to the Mississippi River so that the impact is "insignificant" or "acceptable".

Access to the Mississippi River in the plume discharge area is limited by existing fencing at Site R, a very steep riverbank and the absence of public roads leading to this area. Additional institutional controls would include warning signs posted at the top of the riverbank in the plume discharge area and in nearby river access areas. A public education program would be implemented by the appropriate government agencies to inform the public that fish in the impacted groundwater discharge area may contain site-related constituents and to assure public awareness of the potential risks, if any, that may be associated with consumption of fish caught in the plume discharge area.

Routine maintenance and inspection of the condition and effectiveness of the institutional controls will be performed. For estimating purposes, it is assumed that inspections will be conducted quarterly.

Physical Barrier - A 3,500 ft. long, "U"-shaped, fully penetrating, jet grout barrier wall will be installed between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River (Figure 5-1) to abate the discharge of impacted groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area. It will extend along the entire 2,000 ft. north/south length of Site R with the arms of the "U" extending approximately 750 ft. to the east (upgradient), past the eastern boundary of Site R and terminating before the USACE floodwall.

Three partially penetrating groundwater recovery wells, capable of pumping a combined total of 303 to 724 gpm, will be installed inside the "U"-shaped barrier wall to abate groundwater discharging to the wall. Modeling indicates that groundwater discharges to the Mississippi River for high, average and low river stage conditions are 303, 535 and 724 gpm, respectively (Volume II - Design Basis and Design). Pumping rates will be controlled by river stages as follows:

	River Stage (ft, amsl)	Pumping Rate (gpm)
High Monthly Average River Flow	401	300
	400	325
	399	350
	398	375
	397	400
	396	425
	395	450
	394	475
	393	500
	392	525
Average Monthly Average River Flow	391	535
	390	550
	389	575
	388	600
	387	625
	386	650
	385	675
	384	700
Low Monthly Average River Flow	383	725

Note that zero river stage is at EL379.94 ft, amsl. The highest recorded river stage was +49.58 (EL429.52 ft, amsl) and the lowest recorded stage is -6.2 (EL373.74 ft, amsl).

A river stage gage will be installed in the Mississippi River downgradient of Site R. Water level information from the gage will be sent by telemetry to the pump controller that will adjust the variable frequency drives to produce the required pumping rates to control the groundwater discharging to the barrier wall (Volume II - Design Basis and Design).

Groundwater Treatment - Extracted groundwater will be routed to the American Bottoms Regional Treatment Facility via subsurface pipeline installed in existing pipeline easements starting at the north end of Sauget Area 2 Site R and extending to the western boundary of Lot F. At the western boundary of Lot F, property owned by Solutia, the pipeline will turn south and connect with the Village of Sauget trunk sewer leading to the PChem Plant (Volume II - Design Basis and Design). Existing easements and access points for raw material and finished product pipelines allow ready installation of the extracted groundwater pipeline beneath the floodwall and railroad tracks and avoids the time consuming process of obtaining access and easements on alternative routes. Current plans call for using single wall, thermally welded, HDPE piping to connect the extraction wells to the sewer system. Double wall piping is not considered necessary or appropriate because welded HDPE pipe is not prone to leaking. To ensure pipeline integrity, pressure testing of the pipeline will be conducted on completion of construction, and every five years following placement into operation, to verify that the pipe and joints remain leak proof.

Metals will be removed from the wastewater stream by flocculation and settling at the PChem plant and oil and grease will be removed by physical separation. Wastewater from the PChem plant discharges to the activated-sludge secondary treatment stage at the American Bottoms Regional Treatment Facility. Organic constituents are biodegraded and/or adsorbed on added powdered activated carbon. After settling and solids removal, treated wastewater is discharged to the Mississippi River through a 100 ft. long diffuser located at the north end of Sauget Area 2 Site R. The diffuser terminates approximately 100 ft. from shore.

A discharge permit will need to be obtained from American Bottoms in order to discharge pumped groundwater to the POTW. To obtain this permit, a demonstration will need to be made that constituents in the pumped groundwater will not pass through the POTW without treatment and/or will not interfere with treatment plant operation. A local limits evaluation indicates the potential for two constituents (4-Chloroaniline and 4-Nitroaniline) to pass through the ABRTF without treatment and the potential for four constituents (Aniline, 2-Chlorophenol, Pentachlorophenol and Phenol) to interfere with treatment system operation (Section 2.8). These constituents were successfully treated in a pilot-scale groundwater treatability study performed at Sauget Area 2 Site R in the early 1990s (Section 2.7).

Since the American Bottoms Regional Treatment Facility uses the same treatment processes (biodegradation and carbon adsorption) as were used in the Sauget Area 2 Site R groundwater treatability study, the POTW should be able to treat this groundwater discharge. American Bottoms submitted an NPDES permit renewal application to IEPA in October 2001 that included this groundwater discharge. A discharge permit application for the groundwater discharge will be submitted in April 2002.

Groundwater Quality Monitoring - Groundwater quality samples will be collected downgradient of the physical barrier to determine mass loading to the Mississippi River resulting from any contaminants migrating through, past or beneath the barrier wall. Groundwater quality samples will be collected from four monitoring well clusters and analyzed for VOCs, SVOCs, Herbicides, Pesticides and Metals. TOC and TDS will also be determined for each sample. Monitoring well clusters will be constructed on the top of the riverbank downgradient of the following locations immediately adjacent to the Mississippi River (Figure 5-1):

- 200 ft. South of the North End of Sauget Area 2 Site R
- Halfway Between North and Center Pumping Well
- Halfway Between South and Center Pumping Well
- 200 ft. North of the South End of Site R

Each well cluster will consist of monitoring wells screened in the Shallow, Middle and Deep Hydrogeologic Units. A total of twelve monitoring wells will be installed. Figure 5-1 depicts the planned monitoring well network. Soil samples from borings completed for the purpose of installing groundwater-quality monitoring wells and groundwater extraction wells and/or obtaining geotechnical information on subsurface soils will be screened for the presence of NAPL. In addition, existing wells downgradient of Sauget Area 2 Site R will be measured for accumulation of NAPL.

Groundwater samples will be collected quarterly for five years and semiannually thereafter.

Mass loading to the Mississippi River will be determined for each hydrogeologic unit (SHU, MHU and DHU) using the following equation:

Organic Mass Loading, kg/quarter = $[Q\ (C_{aver.})\ (D)]\ /\ 1000$

Where: Q = Darcy Flow, cubic meters per day

$C_{aver.}$ = Average TOC Concentration, mg/l

D = 90 days per quarter

Inorganic Mass Loading, kg/quarter = [Q ($C_{aver.}$) (D)] / 1000

Where: Q = Darcy Flow, cubic meters per day

$C_{aver.}$ = Average TDS Concentration, mg/l

D = 90 days per quarter

Darcy Flow, cm/day = KIA

Where: K = Hydraulic Conductivity, meters per day
I = Gradient, meters per meter
A = Seepage Area, square meters

Hydraulic conductivities of 0.35, 138 and 104 meters per day will be used for the Shallow, Middle and Deep Hydrogeologic Units.

Gradient in each of these hydrogeologic units will be determined by measuring depth to water in the monitoring well cluster installed downgradient of the north end of Site R and a water-level piezometer cluster installed directly upgradient of this monitoring well cluster on the west side of Route 3 (Mississippi Avenue) on property owned by Solutia (Lot F). This water-level piezometer cluster will be located approximately 1500 ft. south of the northeast corner of Lot F. Depth to water measurements will be converted to water-level elevations. Gradient in each hydrogeologic unit will be determined by subtracting the water-level elevation measured in the monitoring well cluster at the riverbank from the corresponding water-level elevation in the water-level piezometer adjacent to Route 3 and dividing this result by the distance between the two water-level measuring points, i.e.:

Gradient, m/m = ($WLE_{Route\ 3}$ - WLE_{River}) / D

Where: $WLE_{Route\ 3}$ = Water Level Elevation at Route 3, meters amsl
WLE_{River} = Water Level Elevation at River, meters amsl

D = Distance Between Water Level Measuring Points, meters

Seepage areas of the Shallow, Middle and Deep Hydrogeologic Units are given below:

- Shallow Hydrogeologic Unit Seepage Area = (2000 ft. Wide) (20 ft. Deep) = 40,000 $ft.^2$
- Middle Hydrogeologic Unit Seepage Area = (2000 ft. Wide) (30 ft. Deep) = 60,000 $ft.^2$
- Deep Hydrogeologic Unit Seepage Area = (2000 ft. Wide) (40 ft. Deep) = 80,000 $ft.^2$

Converting to metric units, the seepage faces of the SHU, MHU and DHU are, respectively, 3,700 m^2, 5,500 m^2 and 7,300 m^2.

Mass loading for each hydrogeologic unit will be calculated using average TOC and TDS concentration in the unit. Total mass loading to the Mississippi River will be determined by summing the mass loads for the Shallow Hydrogeologic Unit, Middle Hydrogeologic Unit and Deep Hydrogeologic Unit. Total mass loading will be plotted over time to track changes in the amount of mass discharging to the Mississippi River.

Groundwater Level Monitoring - Groundwater level monitoring will be done to ensure acceptable performance of the physical barrier installed to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area. Soil samples from the borings completed for the purpose of installing water-level piezometers will be screened for the presence of NAPL. In addition, existing wells downgradient of Sauget Area 2 Site R will be measured for accumulation of NAPL.

Groundwater levels will be monitored at the physical barrier to determine if gradient control is achieved. Gradient control will be determined by:

- Comparing the water-level elevations in one pair of fully penetrating water-level piezometers installed at the northwest corner of the physical barrier and one pair of piezometers installed at its southwest corner (Figure 5-1). One piezometer of each pair will be installed inside the barrier wall and one will be installed outside it. Pumping wells and water-level piezometers will be located on the same north/south line. Pumping rates will be adjusted so that the water-level elevation in the inside piezometer at each corner of the barrier wall is the same as the water-level elevation in the outside piezometer. This will ensure that groundwater discharging to the physical barrier is controlled. Electronic water-level recorders will be installed in each piezometer and telemetry will be used to send the water-level data to the pump controller. Groundwater elevations inside and outside each corner of the barrier wall will be compared by the pump controller and pumping rates will be adjusted to maintain the same groundwater level elevation inside the barrier wall as measured outside the wall.

- Comparing the water-level elevations in one pair of fully-penetrating water-level piezometers installed halfway between the south pumping well and the center pumping well and one pair installed halfway between the north pumping well and the center pumping well. One piezometer of each pair will be installed on the downgradient side of the barrier wall and the other piezometer will be installed on the upgradient side (Figure 5-1). Pumping wells and water-level piezometers on the upgradient side of the barrier wall will be located on the same north/south line. Water-level piezometers downgradient of the barrier wall will be installed 20 feet away from the wall. Pumping rates will be adjusted so that the water-level elevation in the upgradient piezometer of each pair is the same as the water-level elevation in the downgradient piezometer. This will ensure that groundwater discharging to the physical barrier is controlled. Electronic water-level recorders will be installed in each piezometer and telemetry will be used to send the water-level data to the pump controller. Groundwater elevations inside and outside the north/south portion of the barrier wall will be compared by the pump controller and pumping rates will be adjusted to maintain the same groundwater level elevation inside the barrier wall as measured outside the wall.

- Groundwater levels will be measured manually on a quarterly basis in existing wells B-21B, B-22A, B-24C, B-25A, B-25B, B-26A, B-26B, B-28A, B-28B and B-29B to supplement gradient control information from the water-level piezometers. Wells B-27B, B-23B, B-30B and B-31B and B-31C no longer exist and, therefore, cannot be used to supplement the groundwater level data set.

Physical barrier pumping rates will not be increased to the point where water levels inside the barrier wall are lower that water levels outside the barrier wall. Operating the physical barrier in this manner effectively turns it into a large collection well that will have little or no effect on achieving short-term or long-term performance measures. However, it will potentially have a large adverse impact on the ability of the POTW to treat the increase flow from the hydraulic barrier. Treatment costs will also substantially increase without any corresponding increase in environmental protection.

Surface Water and Sediment Monitoring - Sediment and surface water samples will be collected in the plume discharge area downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to determine the effect of any contaminants migrating through, past or beneath the barrier wall and discharging to the Mississippi River. Impact will be determined by comparing constituent concentrations to site-specific, toxicity-based, protective concentrations derived from existing sediment and surface water chemistry and toxicity data. An Apparent Effects Threshold approach will be used to derive site-specific, protective constituent concentrations for sediments and a Toxic Units approach will be used to derive site-specific, protective constituent concentrations for surface water.

Surface water and sediment samples will be collected at Sediment Sampling Stations - 2, 3, 4, 5 and 9, where toxicity was observed in October/November 2000, and analyzed for VOCs, SVOCs, Herbicides, Pesticides and Metals. Constituent concentrations will be plotted as a function of time and compared to the site-specific, toxicity-based, protective concentrations to determine progress toward achieving these targets.

Sediment and surface water sampling will be conducted twice a year, once during the summer low flow period and once during the winter low flow period, when groundwater discharge to the Mississippi River is high.

5.2.1 Overall Protection of Human Health and the Environment

The June 2001 Ecological Risk Assessment (Menzie-Cura) demonstrated that groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area adversely impacted sediment and surface water in the Mississippi River. In addition, site-specific compounds were present in fish tissue collected in this area at higher concentrations than were detected in fish tissue collected upstream and downstream of the plume discharge area.

Construction and operation of a physical barrier will protect the Mississippi River from adverse ecological impact resulting from impacted groundwater discharge to surface water. Protection will be achieved by capturing impacted groundwater that results in surface water and sediment toxicity and fish tissue bioaccumulation. Performance of groundwater quality, groundwater level and bioaccumulation monitoring will ensure that remedial action objectives are met.

Implementation of institutional controls can reduce and/or control impact on human health by warning the public of the potential risks associated with eating fish caught in the plume discharge area.

5.2.2 Compliance with ARARs

If the Agency waives compliance with ARARs as allowed by guidance (Section 3.3.1), there are no chemical-specific ARARs for an interim remedial action to protect surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area except those that govern the discharge of groundwater to a POTW. A physical barrier remedial alternative, as included in Alternative B, meets the objective of containing the discharge of impacted groundwater to surface water to the point where aquatic impact is reduced to acceptable levels. This alternative will not adversely impact floodplains or wetlands, so it is compliant with location-specific ARARs. Groundwater Alternative B will also achieve compliance with action-specific ARARs.

5.2.3 Long-Term Effectiveness and Permanence

A physical barrier and groundwater extraction wells used for control of impacted groundwater at the downgradient edge of Sauget Area 2 Site R will provide the benefit of preventing groundwater with contaminants in excess of allowable concentrations from discharging to the Mississippi River. The barrier wall and extraction wells, along with monitoring and institutional controls, will provide more long-term effectiveness and permanence than the No Action Alternative

5.2.4 Reduction of Toxicity, Mobility or Volume

This alternative reduces the mobility of groundwater contaminants by providing physical and hydraulic control and removal of affected groundwater before it discharges to the Mississippi River downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area. In the long term, this alternative also reduces the toxicity and volume of groundwater contaminants through the action of natural processes, such as biodegradation, adsorption, dilution, volatilization and chemical reactions with subsurface materials, occurring between the source areas and the hydraulic barrier and by removing and treating impacted groundwater migrating to the Mississippi River.

5.2.5 Short-Term Effectiveness

Physical and hydraulic containment more quickly mitigates the potential for impacted groundwater discharging downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area than the No Action Alternative. The time needed to design, approve, procure, construct and start up the physical containment system is expected to be on the order of 12 months or less.

Implementation of this alternative will present minimal risk to human health and the environment. Potential exposure to soil and/or groundwater while installing the physical barrier and groundwater extraction and monitoring wells or conducting groundwater monitoring will be controlled by the use of appropriate health and safety procedures. Investigation-derived waste and purge water produced during well development and sampling will be managed and disposed of as provided for in an appropriate sampling and analysis plan. Extracted groundwater will be discharged to the Village of Sauget PChem Plant and the American Bottoms Regional Treatment Facility in compliance with applicable standards and permits.

5.2.6 Implementability

Installation of a physical barrier and a three-well groundwater extraction system can be accomplished with conventional materials and equipment. The extraction wells can be expected to have comparatively high maintenance, operation and replacement requirements.

5.2.7 Cost

The cost for this alternative, including capital costs, monitoring and reporting costs and annual maintenance costs, on a present value (PV) basis is as follows.

Description	Capital Cost	O&M Cost (PV)	Total Cost (PV)
Institutional Controls	0	248,181	248,181
Monitoring	80,924	1,764,603	1,848,527
Hydraulic Barrier	6,721,973	323,821	7,045,794
Groundwater Treatment	0	17,446,864	17,446,864
Total	$6,802,897	$19,783,469	$26,586,366

The cost presented above is based on continuing corrective action for 30 years, which is considered appropriate for comparative purposes. A discount rate of 7% was used in the cost calculations. Costs were derived primarily from the ECHOS *Environmental Remediation: Assemblies Cost Book*, 1998. Costs were developed in accordance with USEPA Publication No. 9355.0-75, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July 2000. This is an order-of-magnitude engineering cost estimate that is expected to be within -30 to +50% of the actual project cost. A more complete breakdown of the cost estimate is provided in Table 5-1.

5. 3 Groundwater Alternative C - Hydraulic Barrier

This alternative includes the following elements:

- Institutional Controls
- Hydraulic Barrier
- Groundwater Treatment
- Monitoring
  - Groundwater Quality Monitoring
  - Groundwater Level Monitoring
  - Surface Water and Sediment Monitoring

Institutional controls, groundwater treatment and groundwater quality and sediment and surface water quality monitoring were discussed in Section 5.2 and will not be repeated here.

Hydraulic Barrier - Three partially penetrating groundwater recovery wells, capable of pumping a combined total of 606 to 1,448 gpm, will be installed downgradient of Sauget Area 2 Site R to abate discharge of impacted groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area to the point where the impact on the Mississippi River is reduced to acceptable levels. Modeling indicates that groundwater discharges to the Mississippi River for high, average and low river stage conditions are 160, 535 and 880 gpm, respectively (Volume II - Design Basis and Design). Capture zone theory indicates that a pumping rate of twice the Darcy flow is needed to control the impacted groundwater downgradient of Sauget Area Site R. Consequently, pumping rates need to vary from 606 to 1,448 gpm to control groundwater discharge to surface water. Pumping rates will be controlled by river stages as follows:

	River Stage (ft, amsl)	Pumping Rate (gpm)
High Monthly Average River Flow	401	600
	400	650
	399	700
	398	750
	397	800
	396	850
	395	900
	394	950
	393	1000
	392	1050
Average Monthly Average River Flow	391	1070
	390	1100
	389	1150
	388	1200
	387	1250
	386	1300
	385	1350
	384	1400
Low Monthly Average River Flow	383	1450

Note that zero river stage is at EL379.94 ft, amsl. The highest recorded river stage was +49.58 (EL429.52 ft, amsl) and the lowest recorded stage is -6.2 (EL373.74 ft, amsl).

Groundwater Level Monitoring - Groundwater level monitoring will be done to ensure acceptable performance of the hydraulic barrier installed to abate the impact of groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industrial facilities in the Sauget area.

Groundwater levels will be monitored at the hydraulic barrier to determine if gradient control is achieved. Gradient control will be determined by comparing the water-level elevations in two fully penetrating water-level piezometers to groundwater levels in two downgradient monitoring well clusters adjacent to the Mississippi River (Figure 5-2). One piezometer will be installed half way between the north pumping well and the center pumping well; the other will be installed halfway between the south pumping well and the center pumping well. Pumping wells and water-level piezometers will be located on the same north/south line. Pumping rates will be adjusted so that the water-level elevation in the two piezometers is one foot less that the water level in the Shallow, Middle and Deep Hydrogeologic Units. This will ensure that discharge of impacted groundwater to the Mississippi River is controlled.

Electronic water-level recorders can be installed in each piezometer and telemetry can be used to send the groundwater-level data to the pump controller. Electronic water-level recorders can be installed in the two monitoring well clusters downgradient of the two gradient control water level piezometers to determine groundwater level elevation at the riverbank. Telemetry can be used to send this groundwater level information to the pump controller. Groundwater elevation at the riverbank and groundwater elevation in the gradient control piezometers can be compared by the pump controller and hydraulic barrier pumping rates can be adjusted to maintain a one foot negative differential between them.

Hydraulic barrier pumping rates will not be increased if water levels in the two monitoring-well clusters downgradient of the water-level piezometers are at or below river level elevation. Pumping river water will have little or no effect on achieving short-term or long-term performance measures, however, it will potentially have a large adverse impact on the ability of the POTW to treat the increase flow from the hydraulic barrier. Treatment costs will also substantially increase without any corresponding increase in environmental protection.

One fully penetrating water-level measurement piezometers will be installed north of the northern pumping well and one piezometer will be installed south of the southern pumping well to determine the width of the gradient control zone created by the hydraulic barrier (Figure 5-2).

5.3.1 Overall Protection of Human Health and the Environment

The June 2001 Ecological Risk Assessment (Menzie-Cura) demonstrated that groundwater discharging to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area adversely impacted sediment and surface water in the Mississippi River. In addition, site-specific compounds were present in fish tissue collected in this area at higher concentrations than were detected in fish tissue collected upstream and downstream of the plume discharge area.

Construction and operation of a hydraulic barrier will protect the Mississippi River from adverse ecological impact resulting from impacted groundwater discharge to surface water. Protection will be achieved by capturing impacted groundwater that results in sediment toxicity. Performance of groundwater quality, groundwater level and bioaccumulation monitoring will ensure that remedial action objectives are met.

Implementation of institutional controls can reduce and/or control impact on human health by warning the public of the potential risks associated with eating fish caught in the plume discharge area.

5.3.2 Compliance with ARARs

If the Agency waives compliance with ARARs as allowed by guidance (Section 3.3.1), there are no chemical-specific ARARs for an interim remedial action to protect surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area except those that govern the discharge of groundwater to a POTW. A hydraulic barrier remedial alternative, as included in Alternative C, meets the objective of containing the discharge of impacted groundwater to surface water to the point where aquatic impact is reduced to acceptable levels. This alternative will not adversely impact floodplains or wetlands, so it is compliant with location-specific ARARs. Groundwater Alternative B will also achieve compliance with action-specific ARARs.

5.3.3 Long-Term Effectiveness and Permanence

Extraction wells used for hydraulic containment at the downgradient edge of Sauget Area 2 Site R provide the benefit of preventing groundwater with contaminants in excess of allowable concentrations from discharging to the Mississippi River. The extraction wells will provide more long-term effectiveness and permanence than the No Action Alternative

5.3.4 Reduction of Toxicity, Mobility or Volume

This alternative reduces the mobility of groundwater contaminants by providing hydraulic control and removal of affected groundwater before it discharges to the Mississippi River downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area. In the long term, this alternative also reduces the toxicity and volume of groundwater contaminants through the action of natural processes, such as biodegradation, adsorption, dilution, volatilization and chemical reactions with subsurface materials, occurring between the source areas and the hydraulic barrier and by removing and treating impacted groundwater migrating to the Mississippi River.

5.3.5 Short-Term Effectiveness

The addition of hydraulic containment to performance monitoring and institutional controls more quickly mitigates the potential for impacted groundwater discharging downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area than the No Action alternative. The time needed to design, approve, procure, construct and start up the hydraulic containment system is expected to be on the order of 12 months or less.

Implementation of this alternative will present minimal risk to human health and the environment. Potential exposure to groundwater while installing extraction and groundwater monitoring wells or conducting groundwater monitoring will be controlled by the use of appropriate health and safety procedures. Investigation-derived waste and purge water produced during well development and sampling will be managed and disposed of as provided for in an appropriate sampling and analysis plan. Extracted groundwater will be discharged to the Village of Sauget PChem Plant and the American Bottoms Regional Treatment Facility in compliance with applicable standards and permits.

5.3.6 Implementability

Installation of a three-well, hydraulic-barrier groundwater extraction system can be accomplished with conventional materials and equipment. The extraction wells can be expected to have comparatively high maintenance, operation and replacement requirements.

5.3.7 Cost

The cost for this alternative, including capital costs, monitoring and reporting costs and annual maintenance costs, on a present value (PV) basis is as follows.

Description	Capital Cost	O&M Cost (PV)	Total Cost (PV)
Institutional Controls	0	248,181	248,181
Monitoring	80,924	1,764,603	1,845,527
Hydraulic Barrier	458,679	565,142	1,023,821
Groundwater Treatment	0	47,220,670	47,220,670
Total	$539,603	$49,798,596	$50,338,199

The cost presented above is based on continuing corrective action for 30 years, which is considered appropriate for comparative purposes. A discount rate of 7% was used in the cost calculations. Costs were derived primarily from the ECHOS *Environmental Remediation: Assemblies Cost Book*, 1998. Costs were developed in accordance with USEPA Publication

No. 9355.0-75, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July 2000. This is an order-of-magnitude engineering cost estimate that is expected to be within -30 to +50% of the actual project cost. A more complete breakdown of the cost estimate is provided in Table 5-2.

6.0 COMPARATIVE ANALYSIS OF INTERIM REMEDIAL ALTERNATIVES

In the following sections, Groundwater Remedial Alternatives A (No Action), B (Physical Barrier) and C (Hydraulic Barrier) are compared to one another to identify the relative advantages and disadvantages of each. A forced ranking system was used to identify the alternative that best achieves the requirements of the seven evaluation criteria used to evaluate remedial alternatives. In this forced ranking system, the alternative that best meets the requirements of a criterion was awarded a score of 1, the second best alternative was awarded a score of 2 and the third best alternative was awarded a score of 3. Using this ranking method, the alternative with the lowest score is the one that best meets the requirements of the seven criteria. The comparative analysis is summarized in the following table:

	Alternative A (No Action)	**Alternative B (Physical Barrier)**	**Alternative C (Hydraulic Barrier)**
Overall Protection of Human Health and the Environment	3	1	2
Compliance with ARARs	3	1	2
Long-term Effectiveness and Permanence	3	1	2
Reduction of Toxicity, Mobility or Volume Through Treatment	3	1	2
Subtotal	**12**	**4**	**8**
Short-Term Effectiveness	3	2	1
Implementability	1	3	2
Cost	1	2	3
Subtotal	**5**	**7**	**6**
Total Score	**17**	**11**	**14**

While Alternative A is clearly lower cost and more readily implementable, Alternatives B and C are more effective short term and are the better alternatives for protecting public health and the environment, complying with ARARs, providing long-term effectiveness and permanence and reducing mobility, toxicity or volume. Alternative B scores higher than Alternative C because it provides more long-term effectiveness and permanence and reduction of mobility, toxicity and volume. Alternative B and Alternative C can achieve compliance with ARARs if the Agency considers it appropriate to waive chemical-specific ARARs as allowed by guidance. Alternative B is considered to be better able to achieve ARARs than Alternative C.

6.1 Overall Protection of Human Health and the Environment

Alternative A does not provide for additional protection of human health and the environment.

Alternative B provides for protection of human health by using institutional controls to mitigate potential risks associated with consumption of fish caught in the plume discharge area and installation of a physical barrier to reduce the impact of groundwater discharge to surface water. In addition to institutional controls and groundwater quality, groundwater level and bioaccumulation monitoring, Alternative B includes installation of a 3,500 ft. long, "U"-shaped, fully penetrating, jet grout barrier wall between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River to abate the discharge of impacted groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area. Three partially penetrating groundwater recovery wells, capable of pumping a combined total of 303 to 724 gpm, will be installed inside the "U"-shaped barrier wall to control groundwater discharging to the wall. Alternative B is more protective of human health and the environment than Alternative A.

Alternative C provides for protection of human health by using institutional controls to mitigate potential risks associated with consumption of fish caught in the plume discharge area and installation of a hydraulic barrier to reduce the impact of groundwater discharge to surface water. In addition to institutional controls and groundwater quality, groundwater level and bioaccumulation monitoring, Alternative C includes installation of three partially penetrating groundwater recovery wells, capable of pumping a combined total of 606 to 1,448 gpm between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River to abate the discharge of impacted groundwater from Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.G. Krummrich plant and other industries in the Sauget area.

Alternative C is less protective of human health and the environment than Alternative B because a hydraulic barrier is not as protective as a physical barrier.

6.2 Compliance with ARARs

Alternative A, Alternative B and Alternative C can achieve compliance with ARARs if the Agency considers it appropriate to waive chemical-specific ARARs as allowed by guidance.

6.3 Long-Term Effectiveness and Permanence

Alternative A provides no long-term effectiveness and permanence. Alternative B provides more long-term effectiveness and permanence than Alternative C because it relies on a physical barrier to abate the discharge of groundwater to surface water downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area instead of a hydraulic barrier.

6.4 Reduction of Toxicity, Mobility or Volume through Treatment

Groundwater Alternative A relies on natural processes to reduce the toxicity, mobility and volume of contaminants. Alternative B reduces the mobility of groundwater contaminants by physical control and removal of affected groundwater before it discharges to the Mississippi River downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area. Alternative C reduces the mobility of groundwater contaminants by providing hydraulic control and removal of impacted groundwater. In the long term, both Alternative B and Alternative C reduce the toxicity and volume of groundwater contaminants through the action of natural processes, such as biodegradation, adsorption, dilution, volatilization and chemical reactions with subsurface materials, occurring between the source areas and the hydraulic barrier and by removing and treating impacted groundwater migrating to the Mississippi River. Both Alternatives B and C are more effective than Alternative A in reducing toxicity, mobility or volume. However Alternative B reduces toxicity, mobility and volume more than Alternative C because it relies on a physical barrier instead of hydraulic barrier to reduce mobility.

6.5 Short-Term Effectiveness

Alternative A is not effective in controlling threats to public health and environment in the short term because it relies on long-term, natural processes to reduce the adverse impacts resulting from groundwater discharge to surface water. Natural processes will not reduce adverse impacts on the Mississippi River in the short term.

Alternatives B and C address the primary potential risk to human health by maintaining existing institutional controls and implementing new institutional controls to warn the public of the potential risks, if any, associated with eating fish caught in the plume discharge area. In addition, Alternative B addresses the adverse impacts resulting from groundwater discharge to surface water by the addition of physical containment and Alternative C addresses these impacts by through hydraulic containment. Alternative C more quickly mitigates the adverse surface water impacts resulting from groundwater discharge to the Mississippi River downgradient of Sauget Area 2 Sites O, Q (Dog Leg), R and S; Sauget Area 1 Sites G, H, I and L; the W.K. Krummrich plant and other industrial facilities in the Sauget area because it can be implemented sooner than Alternative B. Consequently, Alternative C is more effective in the short term than Alternative B.

Implementation of Alternative B and Alternative C poses minimal short-term risk to human health and the environment.

6.6 Implementability

Alternative A is more readily implementable than Alternative B or Alternative C because no action is required to implement this alternative.

Alternative C can be implemented more readily than Alternative B because installation of a physical barrier is not included in this alternative. Both Alternative B and Alternative C include groundwater extraction and discharge to the Village of Sauget PChem plant and the American Bottoms Regional Treatment Facility. Additional time will be required to plan, design, procure and install the extraction system and to obtain the permit needed to discharge to the ABRTF. Both of these alternatives are implementable with conventional materials and equipment.

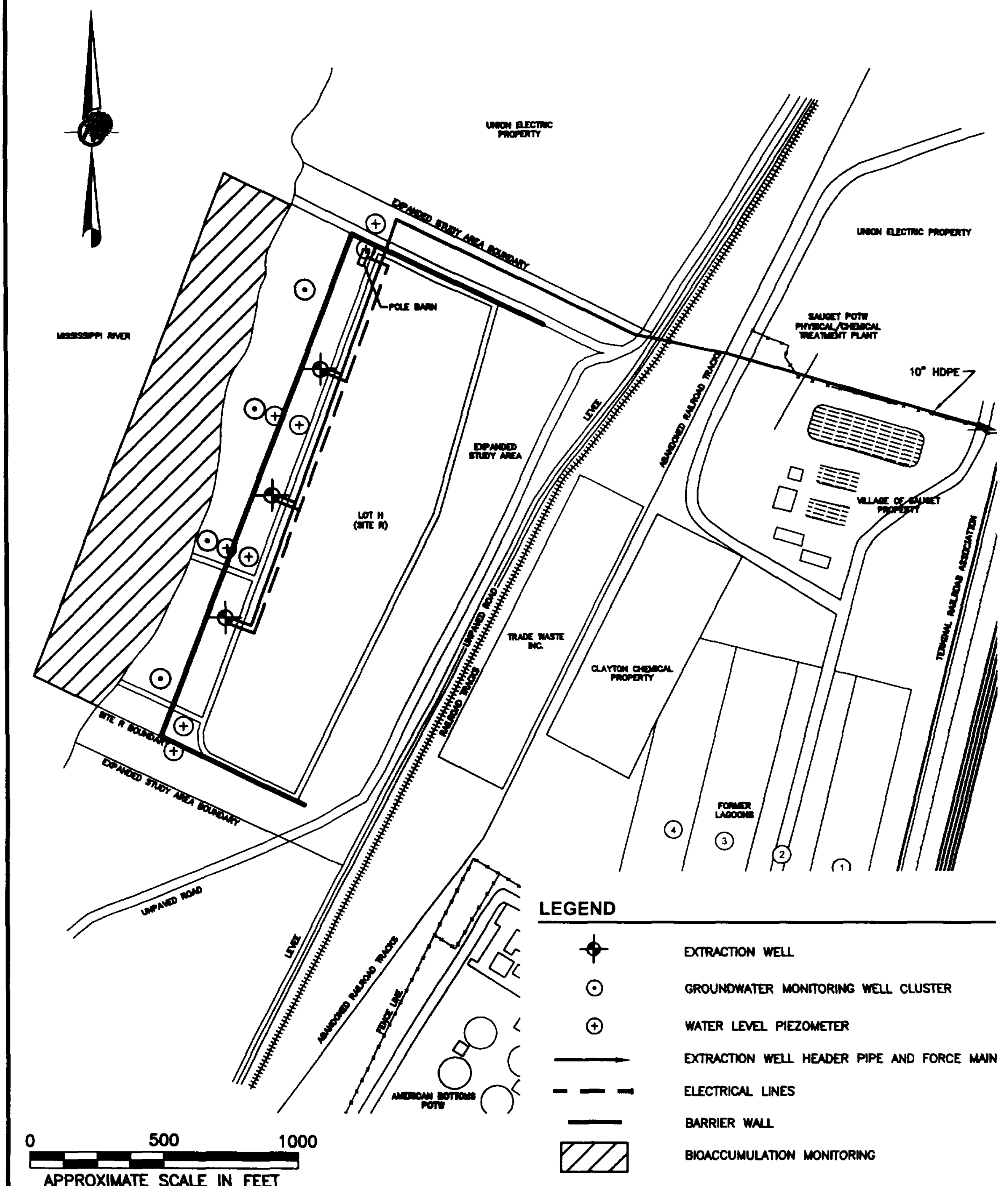
6.7 Cost

No costs are associated with Alternative A. Alternative B ($26.6mm) is significantly less expensive than Alternative C ($50.3MM) on a 30-year present value basis and it provides greater protection of public health and the environment.

Estimated costs for each alternative are summarized below:

Project Element	Alternative B (Physical Barrier)	Alternative C (Hydraulic Barrier)
Institutional Controls	248,181	248,181
Monitoring	1,845,527	1,845,527
Barrier	7,045,794	1,023,821
Groundwater Treatment	17,446,864	47,220,670
30-Year Present Value Cost	$26,586,366	$50,338,199

Estimates for each alternative are included in Tables 5-1 and 5-2.



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<tr><td>CADD MSL</td><td rowspan="3">INTERIM GROUNDWATER REMEDY
FOCUSED FEASIBILITY STUDY
Sauget Area 2, Sauget, Illinois</td><td rowspan="3">FIGURE
1-2</td></tr>
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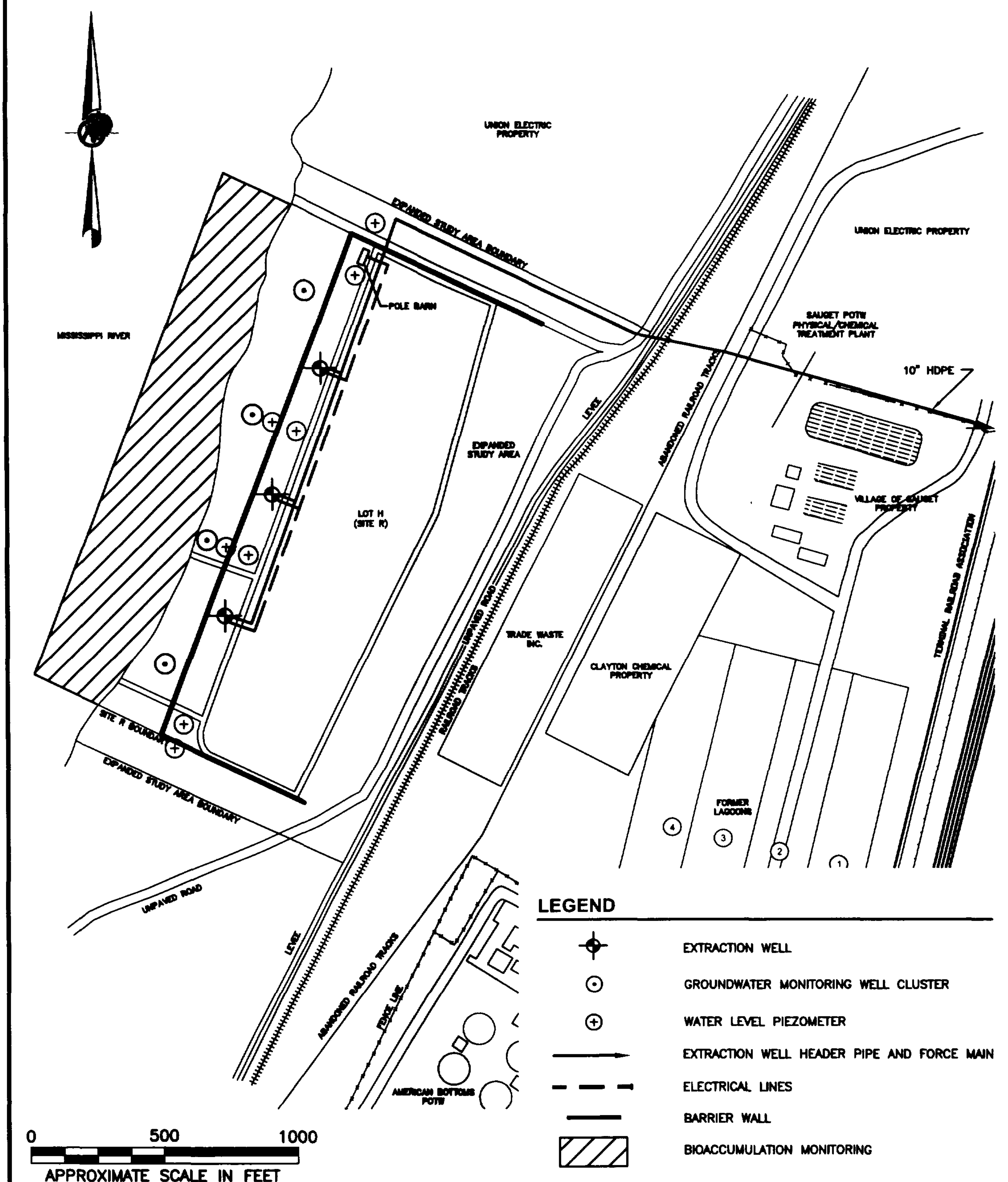

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St. Louis, Missouri

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	CADD MSL		
	CHECK JRS		
	REVIEW		

GROUNDWATER ALTERNATIVE B PHYSICAL BARRIER

INTERIM GROUNDWATER REMEDY
FOCUSED FEASIBILITY STUDY
Sauget Area 2, Sauget, Illinois

FIGURE 5-1